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# REAL-TIME AUXILIARY COMPUTING FACILITY
# APOLLO 7 OPERATIONAL
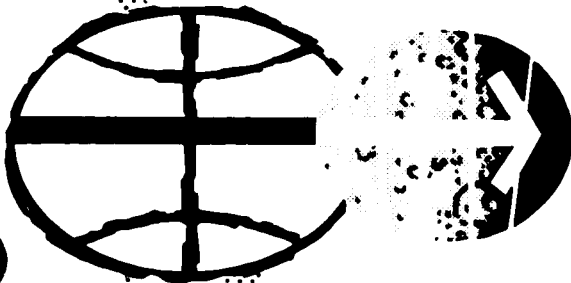# SUPPORT TEAM HANDBOOK

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MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

# REAL-TIME AUXILIARY COMPUTING FACILITY APOLLO 7 OPERATIONAL SUPPORT TEAM HANDBOOK

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October 1, 1968

MISSION PLANNING AND ANALYSIS DIVISION
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

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## CONTENTS

# NOMENCLATURE

| | |
|---|---|
| ABDP | Apollo Block Data Program |
| AGC | Apollo guidance computer |
| ARRS | Apollo Real-Time Rendezvous Support Program |
| ARS | Apollo Reentry Simulation Program |
| BCD | binary coded decimal |
| c.g. | center of gravity |
| CLA | contingency landing area |
| CM | command module |
| CMC | command module computer |
| Col. | column |
| CSM | command and service module |
| DD80 | magnetic tape to microfilm converter |
| DMT | Detailed Maneuver Table |
| ECI | earth centered inertial |
| EI | entry interface |
| FAB | Flight Analysis Branch |
| FAP | FORTRAN Assembly Program |
| FASTRAND | UNIVAC mass storage magnetic drum unit |
| FDO | Flight Dynamics Officer |
| FORTRAN | formula translation |
| GEMMV | General Electric Missile and Satellite Multi-Vehicle Program |
| g.e.t. | ground elapsed time |
| GMT | Greenwich mean time |
| GMTIUGRR | Greenwich mean time of the inertial unit ground reference release |
| GMTL/O | Greenwich mean time of lift-off |

| | |
|---|---|
| GOST | Guidance Optical Support Table |
| GPMP | General Purpose Maneuver Table |
| GRR | guidance reference release |
| IBSYS | IBM system (basic operating system for the IBM 7094) |
| I. D. | identification |
| IMU | inertial measurement unit |
| IU | instrument unit |
| L/D | lift-to-drag ratio |
| LES | launch escape system |
| LET | launch escape tower |
| LO | lift-off |
| LV | launch vehicle |
| LVLH | local vertical/local horizontal |
| MPAD | Mission Planning and Analysis Division |
| MPT | Mission Plan Table |
| MRS | Mass Properties, Reaction Control System, Service Propulsion System Program |
| MSC | Manned Spacecraft Center |
| MSFC | Marshall Space Flight Center |
| NCC | corrective combination maneuver |
| NSR | coelliptic maneuver |
| PCF | Program Control File |
| PGNCS | primary guidance and navigation control system |
| PIT | parameter iteration technique |
| PLA | primary landing area |
| PSAT | Predicted Site Acquisition Table |

| | |
|---|---|
| PVT | pressure-volume-temperature |
| RCS | reaction control system |
| REFSMMAT | reference system to stable member matrix transformation |
| RET | retro elapsed time |
| RTACF | Real-Time Auxiliary Computing Facility |
| RTCC | Real-Time Computing Complex |
| SCS | stabilization control system |
| S-IVB | second stage of the Saturn I-B launch vehicle |
| SPAN | Solar Particle Alert Network |
| SPS | service propulsion system |
| SST | spacecraft systems test |
| SPECUS<br>ARDC<br>USSTD<br>POE<br>SMALL<br>SPECAR | atmospheric models |
| SM | service module |
| TPF | terminal phase finalization maneuver |
| TPI | terminal phase initiation maneuver |
| TRW | TRW Systems Group |
| TUP | Trajectory Update Processor |
| WSP | Work Schedule Processor |
| $\Delta V$ | delta velocity |
| $\Delta T$ | delta time |
| cs | centisecond |
| deg | degree |

er     earth radius

er/hr     earth radii per hour

ft     foot

ft/sec     feet per second

hr     hour

km     kilometer

lb     pound

m     meter

min     minute

m/csec     meters per centisecond

m/sec     meters per second

n mi     nautical mile

sec     second

## Geodetic Spherical Coordinates

$V$     inertial velocity

$\gamma$     inertial flight-path angle

$\psi$     inertial azimuth

$H$     height

$\lambda$     longitude

$\phi_D$     geodetic latitude

## Geocentric Spherical Coordinates

$V$     inertial velocity

$\gamma$     inertial flight-path angle

$\psi$     inertial azimuth

R    radius

$\lambda$    longitude

$\phi_C$    geocentric latitude

Classical Spherical Coordinates

a    semimajor axis

e    eccentricity

i    inclination

g    arguments of perigee

h    longitude of ascending node

l    mean anomaly

# REAL-TIME AUXILIARY COMPUTING FACILITY

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## 1. INTRODUCTION

### 1.1 Purpose

This document presents the operating instructions for the Apollo 7 Real-Time Auxiliary Computing Facility (RTACF) processors and is primarily intended for use by those individuals assigned to the RTACF Apollo 7 Operational Support Team. These processors were developed by the RTACF Operational Support Team to fulfill the RTACF requirements for support of the Apollo 7 mission. A detailed discussion of the requirements and a general description of the processors are presented in Reference 1.

This handbook was prepared through a joint effort by TRW Systems Group and MSC/MPAD. TRW Systems Group participation was accomplished under Task MSC/TRW A-130, Contract NAS 9-4810. (Reference 2).

### 1.2 Method of Presentation

The operating instructions for the RTACF processors have been divided into seven groups because of the different software systems used. The first group, which employs the GEMMV trajectory program, is presented in Section 2. Section 3 presents the GEMMV post processors that are used in conjunction with the GEMMV processors in Section 2. The Work Schedule processor, which is also a GEMMV post processor and is used in conjunction with GEMMV processors, is described separately in Section 4, since it requires a different system setup from the processors

in Section 3. Operation instructions for the Mission Monitor System, comprised of nine different processors that do not require a trajectory program, are given in Section 5. The Orbital Lifetime Program is presented in Section 6. A general description of the Real-Time Rendezvous Support Program and the Apollo Block Data Program are presented in Sections 7 and 8, respectively, while the detailed operating instructions for these programs are contained in References 3 and 4.

# 2. OPERATING INSTRUCTIONS FOR THE GEMMV PROCESSORS

## 2.1 General

This section presents the tape setup and the control cards required to operate the GEMMV processors on the UNIVAC 1108 data processing system. Also presented is a brief description of each processor along with the on-line inputs required for their operation.

## 2.2 Tape Setup for the UNIVAC 1108 Data Processing System

| Tape Unit | Tape Description |
|-----------|------------------|
| A | GEMMV program (PCF) tape |
| B | Mission table tape |
| F | Mission data tape |

## 2.3 Control Card Listing and On-line Deck Setup for the UNIVAC 1108 Data Processing System

| Column 1 | 4 | 8 | |
|----------|---|---|---|
| $ JOB | | | NASA/MSC standard job card |
| * ▽N | HDG | | Comments |
| ▽ | ASG | A = XXXX | Program (PCF) tape number |
| ▽ | ASG | B = XXXX | Mission table tape number |
| ▽ | ASG | F = XXXX | Mission data tape number |
| ▽ | ASG | G, N, V | Scratch units on FASTRAND |
| ▽ | XQT | CUR | Execute the following instructions: |
| | | TRW A, B, F, G, N, V | Rewind units A, B, F, G, N, and V. |
| | | IN A | Read in first file of tape A. |
| | | . | Source language corrections (patches) |
| ▽N | XQT | GEMMV | Execute GEMMV program. |
| | | Xn$ | n is the file number of the data tape. |

2-1

```
Xm$                              m is the number of GEMMV
                                 tables to input.

  .    ⎞
  .    ⎟
  .    ⎬                         GEMMV tables
  .    ⎟
  .    ⎠
A      ⎞
A      ⎟
A      ⎟
       ⎬                         A-array updates for phase 1
  .    ⎟
  .    ⎟
A      ⎠
    TRA 2, 4                      Execute phase 1.
A      ⎞
A      ⎟
A      ⎟
       ⎬                         A-array updates for phase 2
  .    ⎟
  .    ⎟
A      ⎠
    TRA 2, 4                      Execute phase 2.
  .  ⎞
     ⎬                           GEMMV A-array updates and
  .  ⎠                           phase execute cards
  .
A      ⎞
A      ⎟
A      ⎟
       ⎬                         A-array updates for phase N,
  .    ⎟                         where N is the last GEMMV
  .    ⎟                         phase
A      ⎠
    TRA 2, 4                      Execute phase N.
 ** FILE K                        Last card in the GEMMV deck
   ∇EOF                           End of file card
```

* ∇ indicates 7/8 overpunch in Column 1.

** K is the next file to be read from the PCF tape.

## 2.4 The GEMMV Processors

This section presents a brief description of the GEMMV processors and the on-line inputs required to operate each processor. Also included is a figure for each processor that depicts the sequence of the GEMMV phases, the flags used to skip specific phases, the groups of phases that perform functions, and the spans of phases covered by the iterative (PIT) mode and boundary value mode.

2.4.1 <u>Mode I/II Abort Processor.</u> - This processor will be used to calculate any constant lift entry landing point, given a state vector that reflects an entry trajectory. If an abort occurs in the Mode I region defined as the region from lift-off to LET jettison and the state vector reflects the LET delta velocity, or if an abort occurs in the Mode II region defined as the region after LET jettison plus 15 seconds to the time when a full lift entry profile results in a downrange landing greater than 3200 nautical miles, this processor will be used to predict a ballistic landing point.

The Mode I/II abort is simulated by the GEMMV program by employing the following logic. The input vector is integrated forward in Phase I until the altitude is either 400,000 feet or 200,000 feet. Phase 11 is executed next, and if the altitude is either 200,000 or 400,000 feet and the flight-path angle is negative, no integration takes place in that phase. However, if the altitude is 400,000 feet and the flight-path angle is positive, the vector is integrated forward until the altitude is again 400,000 feet. Phase 14 is executed next, and the vector is integrated forward to drogue chute deployment.



MODE II ABORT LOGIC
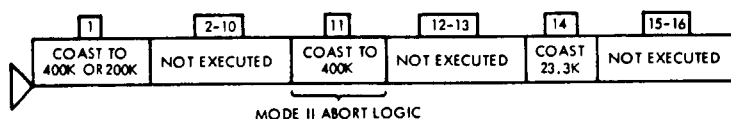
# MODE I/II ABORT PROCESSOR

## (Special Mode I/II Abort Deck; File 1; UNIVAC 1108)

A.  This processor must always be run with the special Mode I/II abort patch

B.  Standard GEMMV input quantities for the Mode I/II deck are listed below:

PHASE 1 - INITIAL COAST PHASE

### Initialization

| | |
|---|---|
| A4871-3 | Vector identification |
| A368 | Revolution number |
| A93-5 | Lift-off time (hr, min, sec) (GMT) |
| A1138-40 | Vector time (hr, min, sec) (GMT) |
| A240-2 | Position coordinates (er) (X, Y, Z) |
| A248-50 | Velocity coordinates (er/hr) ($\dot{X}$, $\dot{Y}$, $\dot{Z}$) |
| A280 | Entry weight (lb) |

### Additional Updates

| | |
|---|---|
| A904 | Entry weight (lb) |
| A647* | Set to 2 (number of terminating conditions). |
| A648* | Set to 245 (terminate on altitude). |
| A649* | Set to 400,000 (termination value). |
| A651* | Set to 245 (terminate on altitude). |
| A652* | Set to 200,000 (termination value). |
| A902* | Set to 0 (bank angle). |
| A905-11* | Set all to 1 (flags to skip appropriate phases). |
| A1172* | Set to -1 (entry lift multiplier). |
| A1906* | Set to 1 (no iteration). |

PHASE 2 - (NOT EXECUTED)

PHASE 3 - (NOT EXECUTED)

PHASE 4 - (NOT EXECUTED)

PHASE 5 - (NOT EXECUTED)

| | |
|---|---|
| A-150* | Set to 1 to skip this phase. |

PHASE 6 - (NOT EXECUTED)

PHASE 7 - (NOT EXECUTED)

PHASE 8 - (NOT EXECUTED)

PHASE 9 - (NOT EXECUTED)

    A150*          Set to 1 to skip this phase.

PHASE 10 - (NOT EXECUTED)

PHASE 11 - COAST TO 400,000 FEET

    A85*          Set to 1 (turn on Mode II abort logic).

PHASE 12 - (NOT EXECUTED)

    A150*          Set to 1 to skip this phase.

PHASE 13 - (NOT EXECUTED)

PHASE 14 - COAST TO 23,300 FEET

PHASE 15 - MAXIMUM LIFT FOOTPRINT EXECUTION

PHASE 16 - MINIMUM LIFT FOOTPRINT EXECUTION

*These A-arrays have already been set to the correct values in the special Mode I/II on-line deck.

2.4.2 <u>Mode III and Fixed Delta V Abort Processor.</u> - This processor
will be used to determine the SPS velocity increment and IMU gimbal
angles at ignition required to achieve a longitude or 3200-nautical mile
downrange target landing point.  It may also be used to determine the
landing point, given a state vector, the SPS ignition time, a burn attitude,
and the delta velocity of the burn.  The Mode III abort is simulated by
performing an SPS retrograde burn of up to 1400 feet per second in a
horizon monitor attitude and by flying an entry profile consisting of an
180-degree bank angle to a 0.2-g load and a 55-degree south bank angle to
drogue chute deployment.  For the Fixed Delta V abort, this processor
will be used to determine SPS ignition time and the IMU angles at ignition
required to achieve a longitude or an 8800-nautical mile downrange
landing.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15-16 |
|---|---|---|---|---|---|---|---|---|----|----|----|----|----|-------|
| COAST | A905 RCS | A906 SPS | A905 COAST | COAST | A907 RCS | A908 SPS | A909 COAST | RCS | A910 SPS | 400K | 300K | A911 XGS | 23.3K | A933 |
| | | | | | | | | | | | | | | MAX   MIN |

FIXED TIME SEP     $\Delta T \approx 0$     FIXED $\Delta T$ SEP     DEORBIT BURN     ENTRY     FOOTPRINT

PIT MODE
(FIXED $\Delta V$ ABORT)

PIT MODE
( MODE III ABORT)

# MODE III AND FIXED DELTA V ABORT PROCESSOR

## (Special Mode III Abort Deck; File 1; UNIVAC 1108)

A. Standard GEMMV input quantities for the Mode III deck are listed below:

PHASE 1 - INITIAL COAST PHASE

### Initialization

| | |
|---|---|
| A4871-3 | Vector identification |
| A368 | Revolution number |
| A93-5 | Lift-off time (hr, min, sec) (GMT) |
| A1138-40 | Vector time (hr, min, sec) (GMT) |
| A240-2 | Position coordinates (er) (X, Y, Z) |
| A248-50 | Velocity coordinates (er/hr) ($\dot{X}$, $\dot{Y}$, $\dot{Z}$) |
| A280 | Current weight (lb) |

### Orbit Maneuver

| | |
|---|---|
| A1148-50 | Time of RCS ignition (hr, min, sec) (g.e.t.) |
| A1018-26 | REFSMMAT stored row-wise (not necessary if REFSMMAT is computed at ignition) |
| A912 | Flag to compute REFSMMAT at deorbit ignition (Since already set to 1 on tape, set to 0 only if REFSMMAT is input.) |
| A913-5 | IMU roll, pitch, and yaw gimbal angles, respectively (necessary if REFSMMAT is computed or if alignment option 6 is specified) |
| A925-7 | Body roll, pitch, and yaw, respectively, which correspond to alignment option |
| A928-9 | Termination index and value, respectively, of SPS burn |

### Entry

| | |
|---|---|
| A1902 | Longitude of target |
| A904 | Entry weight (lb) |
| A933 | Set to 0 if footprint is desired. |

A932*        Guidance option (Set to 4.)

A924*        Alignment option (Set to 4.)

A905-11*     Flags to skip appropriate phases

A2907*       Set to specified g-level to initiate the entry mode. (Set to 0.2.)

A901*        Lift vector orientation (bank angle) flown to a specified g-level (Set to 0.)

A902*        Lift vector orientation (bank angle) flown from a specified g-level (Set to 55.)

A1172*       Entry lift multiplier (Set to -1.)

PHASE 2 - FIXED TIME RCS SEPARATION

PHASE 3 - FIXED TIME SPS SEPARATION

PHASE 4 - COAST AFTER FIXED TIME SEPARATION

PHASE 5 - COAST TO DEORBIT BURN

PHASE 6 - RCS SEPARATION AT FIXED TIME PRIOR TO DEORBIT

PHASE 7 - SPS SEPARATION AT FIXED TIME PRIOR TO DEORBIT

PHASE 8 - COAST FROM SEPARATION TO DEORBIT

PHASE 9 - RCS ULLAGE PRIOR TO DEORBIT BURN

PHASE 10 - SPS DEORBIT BURN

PHASE 11 - COAST TO 400K FEET
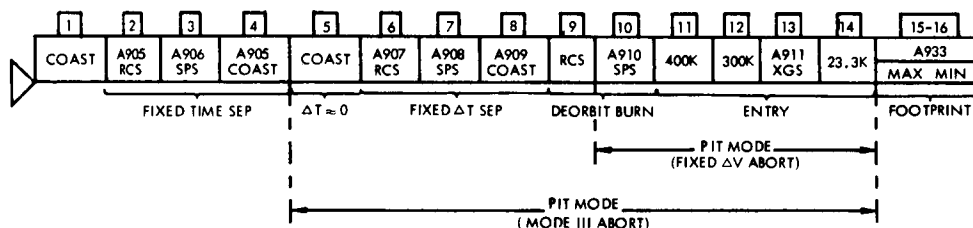
PHASE 12 - COAST TO 300K FEET

PHASE 13 - COAST TO X-G POINT

PHASE 14 - COAST TO 23.3K FEET

PHASE 15 - MAXIMUM LIFT FOOTPRINT EXECUTION

PHASE 16 - MINIMUM LIFT FOOTPRINT EXECUTION

B.  If an impact point is desired given the time of ignition and $\Delta V$ of the SPS burn, set in addition the following index:

PHASE 1 - INITIAL COAST PHASE

A1906        Set to 1 to suppress iteration.

C. To compute the ΔV of the SPS burn to attain a specified range or longitude given the time of ignition, set in addition the following indices:

PHASE 1 - INITIAL COAST PHASE

| | |
|---|---|
| A1901 | Set to 0 to call special iteration in PIT mode. |
| A147 | Set to 6 to start iterative loop at beginning of SPS deorbit phase. |
| A148-9 | Target index and value, respectively, for PIT mode |

D. To compute the time of ignition to attain a specified range or longitude given the velocity increment, set in addition the following indices:

PHASE 1 - INITIAL COAST PHASE

| | |
|---|---|
| A1901 | Set to 0 to call special iteration in PIT mode. |
| A147 | Set to 1 to begin iterative loop. |
| A148-9 | Target index and value, respectively, for PIT mode |

*These A-arrays have already been set to the correct values in the special Mode III on-line deck.

2.4.3 <u>Mode IV Abort and Apogee Kick Processor.</u> - This processor will be used to determine the SPS velocity increment and the IMU gimbal angles at ignition required to achieve a 75-nautical mile perigee given a post S-IVB/CSM separation vector and a SPS ignition time. It will simulate both the Mode IV abort and apogee kick maneuver for performing the SPS burn in a horizon monitor attitude. The output is in the form of the Detailed Maneuver Table (DMT).
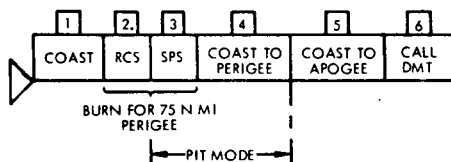
# MODE IV ABORT AND APOGEE KICK PROCESSOR

## (File 5; UNIVAC 1108)

Standard GEMMV input quantities for the Mode IV Abort and Apogee Kick deck are listed below:

PHASE 1 - INITIAL COAST PHASE

### Initialization

| | |
|---|---|
| A4871-3 | Vector identification |
| A368 | Revolution number |
| A93-5 | Lift-off time (hr, min, sec) (GMT) |
| A1138-40 | Vector time (hr, min, sec) (GMT) |
| A240-2 | Position coordinates (er) (X, Y, Z) |
| A248-50 | Velocity coordinates (er/hr) ($\dot{X}$, $\dot{Y}$, $\dot{Z}$) |
| A280 | Current weight (lb) |

### Orbit Maneuver

| | |
|---|---|
| A1148-50 | Time of RCS ignition (hr, min, sec) (g.e.t.) |
| A1018-26 | REFSMMAT stored row-wise |
| A912 | Set to 0 on tape (input REFSMMAT). |
| A225 | Alignment option (Set to 4 on tape, horizon monitor.) |
| A1118-20 | Body roll, pitch, and yaw angles, respectively |
| A930 | Guidance option (Set to 4 on tape, SCS guidance-SPS burn.) |

PHASE 2 - RCS 15-SECOND ULLAGE

PHASE 3 - SPS BURN FOR 75-N MI PERIGEE

PHASE 4 - COAST TO PERIGEE

PHASE 5 - COAST TO APOGEE

PHASE 6 - SHORT DURATION COAST TO CALL DMT

2.4.4 <u>Orbital Maneuver Processor.</u> - This processor will be used to simulate any SPS or RCS orbital maneuver for which the burn quantities have previously been determined.   The output display for this processor will be a DMT.

| 1 | 2-8 | 9 | 10 | 11 | 12 | 13 | 14-20 |
|---|---|---|---|---|---|---|---|
| COAST | NOT EXECUTED | RCS | A910 SPS | COAST TO APOGEE OR PERIGEE | COAST TO APOGEE OR PERIGEE | CALL DMT | COAST |
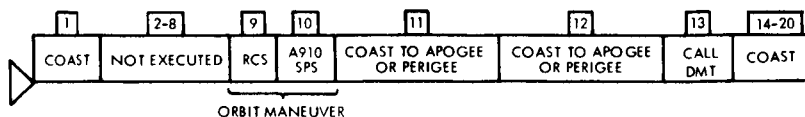
ORBIT MANEUVER

# ORBITAL MANEUVER PROCESSOR

## (File 7; UNIVAC 1108)

A. Standard GEMMV input quantities for the Orbital Maneuver deck are listed below:

PHASE 1 - COAST TO ORBIT MANEUVER

### Initialization

| | |
|---|---|
| A905-11 | Flags to skip appropriate phases |
| A4871-3 | Vector identification |
| A368 | Revolution number |
| A93-5 | Lift-off time (hr, min, sec) (GMT) |
| A1138-40 | Vector time (hr, min, sec) (GMT) |
| A240-2 | Position coordinates (er) (X, Y, Z) |
| A248-50 | Velocity coordinates (er/hr) ($\dot{X}$, $\dot{Y}$, $\dot{Z}$) |
| A280 | Current weight (lb) |

### Orbital Maneuver

| | |
|---|---|
| A1148-50 | Time of RCS ignition (hr, min, sec) (g.e.t.) |
| A1018-26 | REFSMMAT stored row-wise (not necessary if REFSMMAT is computed at ignition) |
| A912 | Flag to compute REFSMMAT at deorbit ignition (Since already set to 1 on tape, set to 0 only if REFSMMAT is input.) |
| A913-5 | IMU roll, pitch, and yaw gimbal angles, respectively (necessary if REFSMMAT is computed or if alignment option 6 is specified) |
| A924 | Alignment option |
| A925-7 | Body roll, pitch, and yaw, respectively, which correspond to alignment option . |
| A932 | Guidance option |
| A941-2 | Termination index and value, respectively, of RCS burn |
| A928-9 | Termination index and value, respectively, of SPS burn |
| A158 | BCD comment card (change phase header) |

PHASE 2 - (NOT EXECUTED)

PHASE 3 - (NOT EXECUTED)

PHASE 4 - (NOT EXECUTED)

PHASE 5 - (NOT EXECUTED)

PHASE 6 - (NOT EXECUTED)

PHASE 7 - (NOT EXECUTED)

PHASE 8 - (NOT EXECUTED)

PHASE 9 - RCS ULLAGE PRIOR TO ORBIT MANEUVER

PHASE 10 - SPS ORBIT MANEUVER

    A120         Integration interval (Must be set to 0. 25 sec only when orbital maneuver burn is less than 0. 50 sec.)

PHASE 11 - COAST TO APOGEE OR PERIGEE

PHASE 12 - COAST TO APOGEE OR PERIGEE

PHASE 13 - SHORT DURATION COAST

PHASE 14 - COAST FOR 1 SEC

    A139         Set to 1 to terminate run.

PHASES 15-20 - COAST FOR 1 SEC

B.  If a navigation update is required at 12 minutes prior to SPS ignition, set in addition the following indices:

PHASE 1 - COAST TO ORBIT MANEUVER

    A1148-50         G. e. t. which is 12 minutes prior to SPS ignition (hr, min, sec) (This should replace the RCS ignition time.)

    A4270         Set to 1 to obtain navigation update at the end of the first phase.

PHASE 8 - COAST FROM FIXED $\Delta$T SEPARATION TO DEORBIT

    A648-9         Termination index and value, respectively (Normally, the index should be 123, and the value should be 705 sec.)

C. If P-40 $\Delta V$'s or P-30 $\Delta V$'s and $\Delta V$ residuals in the RCS control axes are to be input, set in addition the following indices:

PHASE 1 - INITIAL COAST PHASE

A925          Roll angle at ignition (LVLH)

PHASE 9 - ULLAGE PRIOR TO DEORBIT BURN

A996-8       Residual $\Delta V_x$, $\Delta V_y$, $\Delta V_z$ input, respectively

A999-1001    P-40 $\Delta V_x$, $\Delta V_y$, $\Delta V_z$ input, respectively
    or

A987-9       P-30 $\Delta V_x$, $\Delta V_y$, $\Delta V_z$ input, respectively

2.4.5 <u>Maneuver Evaluation Processor</u>. - This processor will be used to evaluate the accuracy to which the CSM performed a planned maneuver. It determines the actual external $\Delta V$ components and space-craft attitude used in performing the maneuver, given a state vector before and after an orbital maneuver, the REFSMMAT, and the ignition time of the maneuver.

The maneuver evaluation is performed by the GEMMV program by employing the following logic. Preburn and postburn vectors are input; the preburn vector is integrated to the postburn vector time; then both vectors are integrated back to the time of ignition. The vectors are compared, and the velocity difference is resolved into the proper coordinate systems.
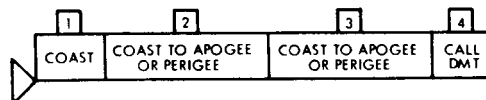
# MANEUVER EVALUATION PROCESSOR

## (Special Maneuver Evaluation Deck; File 4; UNIVAC 1108)

A.  Standard GEMMV input quantities for the Maneuver Evaluation deck are listed below:

PHASE 1 - COAST PREBURN VECTOR TO POSTBURN VECTOR TIME AND COAST BOTH VECTORS TO TIME OF IGNITION

### Preburn Vector

| | |
|---|---|
| A4871-3 | Vector identification |
| A368 | Revolution number |
| A93-5 | Lift-off time (hr, min, sec) (GMT) |
| A1138-40 | Vector time (hr, min, sec) (GMT) |
| A240-2 | Position coordinates (er) (X, Y, Z) |
| A248-50 | Velocity coordinates (er/hr) ($\dot{X}$, $\dot{Y}$, $\dot{Z}$) |
| A280 | Preburn weight (lb) |

### Postburn Vector

| | |
|---|---|
| A1368 | Revolution number |
| A2138-40 | Vector time (hr, min, sec) (GMT) |
| A1240-2 | Position coordinates (er) (X, Y, Z) |
| A1248-50 | Velocity coordinates (er/hr) ($\dot{X}$, $\dot{Y}$, $\dot{Z}$) |
| A1280 | Postburn weight (lb) |

### Additional Updates

| | |
|---|---|
| A1018-26 | REFSMMAT stored row-wise |
| A1118 | Roll angle at ignition (LVLH) |
| A1148-50 | Ignition time (hr, min, sec) (g.e.t.) |
| A910 | Set to 1 for RCS, or 0 for SPS burns. |
| A96* | Set to 1 (flag to result in preburn vector being integrated to postburn vector time). |
| A117* | Set to 2 (highest vehicle capability being used). |
| A99* | Set to 1 (flag to call maneuver evaluation logic). |

PHASE 2 - COAST TO APOGEE OR PERIGEE

A648-9*          Termination index and value, respectively
                 (Normally the index will be 315, flight-path angle,
                 and the value will be 0.)

PHASE 3 - COAST TO APOGEE OR PERIGEE

PHASE 4 - SHORT DURATION COAST

A648-9*          Termination index and value, respectively (10 sec
                 coast)

PHASE 6 - RUN TERMINATION

A139*            Set to 1 to terminate run.

B.  If the preburn or postburn vectors are in the Besselian coordinate
    system, set A211 or A1211 to 1, respectively, in Phase 1.

*These A-arrays have already been set to the correct value in the special
maneuver evaluation on-line deck.

2.4.6 Average-G Navigation Evaluation Processor. - This processor will be used to determine whether it is necessary to perform a navigation update prior to a planned maneuver.

The navigation update evaluation is performed by the GEMMV program by employing the following logic. A spacecraft telemetry vector and a RTCC state vector are input in Phase 1 and propagated to the maneuver time. The maneuver is simulated using the telemetry vector and CMC guidance. Then the incremental velocities throughout the simulation are applied to the RTCC state vector.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| COAST | RCS | SPS | COAST TO APOGEE OR PERIGEE | COAST TO APOGEE OR PERIGEE | CALL DMT | COAST TO APOGEE OR PERIGEE | COAST TO APOGEE OR PERIGEE | CALL DMT |
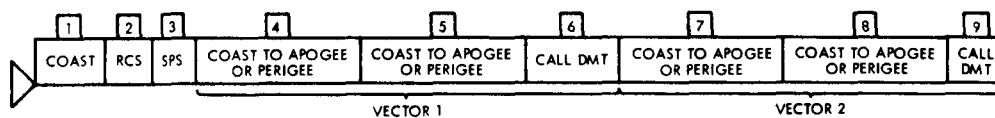
VECTOR 1                          VECTOR 2

# AVERAGE-G NAVIGATION EVALUATION PROCESSOR

## (File 9; UNIVAC 1108)

A. Standard GEMMV input quantities for Average-g deck are listed below:

### PHASE 1 - COAST TO ULLAGE PHASE

#### Vector 1

| | |
|---|---|
| A4871-3 | Vector identification |
| A368 | Revolution number |
| A93-5 | Lift-off time (hr, min, sec) (GMT) |
| A1138-40 | Vector time (hr, min, sec) (GMT) |
| A240-2 | Position coordinates (er) (X, Y, Z) |
| A248-50 | Velocity coordinates (er/hr) ($\dot{X}$, $\dot{Y}$, $\dot{Z}$) |
| A280 | Current weight (lb) |

#### Vector 2

| | |
|---|---|
| A2138-40 | Vector time (hr, min, sec) (GMT) |
| A1240-2 | Position coordinates (er) (X, Y, Z) |
| A1248-50 | Velocity coordinates (er/hr) ($\dot{X}$, $\dot{Y}$, $\dot{Z}$) |
| A1280 | Current weight (lb) |
| A96 | Set to 1 if vector times are different. |

#### Orbit Maneuver

| | |
|---|---|
| A1148 | Time of RCS ignition (hr, min, sec) (g.e.t.) |
| A1018-26 | REFSMMAT stored row-wise (not necessary if REFSMMAT is computed at ignition) |
| A912 | Flag to compute REFSMMAT at ignition (Since already set to 1 on tape, set to 0 only if REFSMMAT is input.) |
| A913-5 | IMU roll, pitch, and yaw gimbal angles, respectively (necessary if REFSMMAT is computed) |
| A924 | Alignment option |
| A925-7 | Body roll, pitch, and yaw angles, respectively, which correspond to alignment option |
| A932 | Guidance option |

A941-2         Termination index and value, respectively, of RCS ullage burn

A928-9         Termination index and value, respectively, of SPS maneuver

PHASE 2 - RCS ULLAGE PHASE

PHASE 3 - SPS MANEUVER PHASE

PHASE 4 - COAST TO FIRST GAMMA STOP (Vector 1)

PHASE 5 - COAST TO SECOND GAMMA STOP (Vector 1)

PHASE 6 - TEN-SECOND COAST; CALL DMT (Vector 1)

PHASE 7 - COAST TO FIRST GAMMA STOP (Vector 2)

PHASE 8 - COAST TO SECOND GAMMA STOP (Vector 2)

PHASE 9 - TEN-SECOND COAST: CALL DMT (Vector 2)

PHASE 10 - RUN TERMINATION

A139         Set to 1 to terminate run.

2.4.7 <u>Contingency Landing Area (CLA) Processor</u>. - This processor
will be used to determine the deorbit maneuver ignition time required to
achieve a target longitude which is normally located in a contingency
landing area. This processor has the capability to simulate a maneuver
at a fixed time or at a specified time interval prior to the deorbit maneu-
ver, and an entry profile consisting of a constant lift vector orientation to
a specified g-load, and then a constant bank angle to drogue chute deploy-
ment. This processor can also simulate a zero and full lift entry profile.
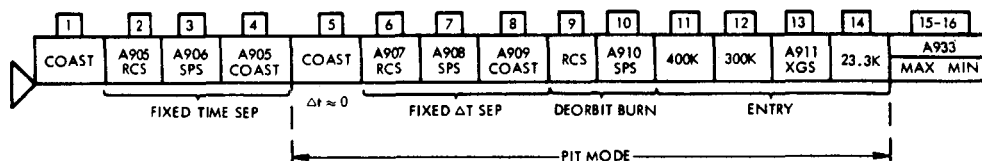
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15-16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

| COAST | A905 RCS | A906 SPS | A905 COAST | COAST | A907 RCS | A908 SPS | A909 COAST | RCS | A910 SPS | 400K | 300K | A911 XGS | 23.3K | A933 MAX MIN |

FIXED TIME SEP    $\Delta t \approx 0$    FIXED $\Delta T$ SEP    DEORBIT BURN    ENTRY

PIT MODE

2-26

A. Standard GEMMV input quantities for the CLA deck are listed below:

PHASE 1 - INITIAL COAST PHASE

## Initialization

| | |
|---|---|
| A905-11 | Flags to skip appropriate phases |
| A4871-3 | Vector identification |
| A368 | Revolution number |
| A93-5 | Lift-off time (hr, min, sec) (GMT) |
| A1138-40 | Vector time (hr, min, sec) (GMT) |
| A240-2 | Position coordinates (er) (X, Y, Z) |
| A248-50 | Velocity coordinates (er/hr) ($\dot{X}$, $\dot{Y}$, $\dot{Z}$) |
| A280 | Current weight (lb) |
| A1906 | Iteration flag (Already set to 0 on tape; set to 1 to suppress iteration.) |

## Fixed Time Maneuver

| | |
|---|---|
| A1148-50 | Time of RCS ignition (hr, min, sec) (g.e.t.) |
| A916 | Alignment option for maneuver |
| A917-9 | Body roll, pitch, and yaw angles, respectively, which correspond to the alignment option |
| A931 | Guidance option for maneuver |
| A920-1 | Termination index and value, respectively, of RCS burn |
| A922-3 | Termination index and value, respectively, of SPS burn |

## Fixed Δt Maneuver

| | |
|---|---|
| A1148-50 | Time of RCS ignition (hr, min, sec) (g.e.t.) |
| A97 | Number of seconds after the fixed Δt maneuver initiation that phase 8 is to terminate (Set to a large number if a termination is input for phase 8.) |
| A916 | Alignment option for maneuver |
| A917-9 | Body roll, pitch, and yaw angles, respectively, which correspond to the alignment option |

| A931 | Guidance option for maneuver |
|---|---|
| A920-1 | Termination index and value, respectively, of RCS burn |
| A922-3 | Termination index and value, respectively, of SPS burn |

### Deorbit Maneuver

| A1148-50 | Time of RCS ignition (hr, min, sec) (g. e. t.) If a fixed time maneuver has been performed, set A1148-50 in phase 4 instead of phase 1. |
|---|---|
| A1018-26 | REFSMMAT stored row-wise (not necessary if REFSMMAT is computed at ignition) |
| A912 | Flag to compute REFSMMAT at deorbit ignition (Since already set to 1 on tape, set to 0 only if REFSMMAT is input.) |
| A913-5 | IMU roll, pitch, and yaw gimbal angles, respectively (necessary if REFSMMAT is computed or if alignment option 6 is specified) |
| A924 | Alignment option |
| A925-7 | Body roll, pitch, and yaw, respectively, which correspond to alignment option |
| A932 | Guidance option |
| A941-2 | Termination index and value, respectively, of RCS burn |
| A928-9 | Termination index and value, respectively, of SPS deorbit burn |

### Entry

| A901 | Lift vector orientation (bank angle) flown to a specified g-level (used only if A911 is set to 0) |
|---|---|
| A902 | Lift vector orientation (bank angle) flown from a specified g-level (if A911=0) or from 300K feet (if A911=1) |
| A1902 | Longitude of target |
| A911 | Set to 0 to execute the coast to X- g's phase. |
| A2907 | Set to specified g-level to initiate the entry mode (necessary only if A911 is set to 0). |
| A1172 | Entry lift multiplier to be used from a specified g-level (if A911=0) or from 300K feet (if A911=1) |
| A904 | Entry weight (lb) |
| A933 | Set to 0 if footprint is desired. |

2-28

PHASE 2 - FIXED TIME RCS SEPARATION

PHASE 3 - FIXED TIME SPS SEPARATION

PHASE 4 - COAST AFTER FIXED TIME SEPARATION

PHASE 5 - COAST TO DEORBIT BURN

PHASE 6 - RCS SEPARATION AT FIXED TIME PRIOR TO DEORBIT

PHASE 7 - SPS SEPARATION AT FIXED TIME PRIOR TO DEORBIT

PHASE 8 - COAST FROM SEPARATION TO DEORBIT

PHASE 9 - RCS ULLAGE PRIOR TO DEORBIT BURN

PHASE 10 - SPS DEORBIT BURN

PHASE 11 - COAST TO 400K FEET

PHASE 12 - COAST TO 300K FEET

PHASE 13 - COAST TO X-G POINT

PHASE 14 - COAST TO 23.3K FEET

PHASE 15 - MAXIMUM LIFT FOOTPRINT EXECUTION

PHASE 16 - MINIMUM LIFT FOOTPRINT EXECUTION

B.  If a navigation update is required at 12 minutes prior to deorbit
    ignition, set in addition the following indices:

PHASE 1 - INITIAL COAST

    A1148-50       G. e. t. which is 12 minutes prior to deorbit ignition
                           (hr, min, sec) (This should replace the RCS ignition
                           time.)

    A909            Set to 0 so that the coast from separation to deorbit
                           phase will be executed. (This phase will be used to
                           execute the navigation update.)

PHASE 5 - COAST TO DEORBIT BURN

    A4270          Set to 1 to execute navigation update at end of this
                           phase.

## PHASE 8 - COAST FROM SEPARATION TO DEORBIT

A649          Set to 705 to terminate this coast 705 seconds prior to RCS ullage. (In case of an RCS deorbit burn this value should be set to 720 seconds.)

C.  If P-40 $\Delta V$'s or P-30 $\Delta V$'s and $\Delta V$ residuals in the RCS control axes are to be input, set in addition the following indices:

## PHASE 1 - INITIAL COAST PHASE

A925          Roll angle at ignition (LVLH)

## PHASE 9 - ULLAGE PRIOR TO DEORBIT BURN

A996-8          Residual $\Delta V_x$, $\Delta V_y$, $\Delta V_z$ input, respectively

A999-1001          P-40 $\Delta V_x$, $\Delta V_y$, $\Delta V_z$ input, respectively
    or
A987-9          P-30 $\Delta V_x$, $\Delta V_y$, $\Delta V_z$ input, respectively

D.  If it is desired to iterate on $\Delta V$ while holding time of ignition fixed, set in addition the following indices:

## PHASE 1 - INITIAL COAST PHASE

A1901          Set to 0 to call special iteration in PIT mode.

A147          Set to 6 to start iterative loop at beginning of SPS deorbit phase.

A148-9          Target index and value, respectively, for PIT mode

E.  If it is desired to compute a REFSMMAT at some time other than deorbit ignition, set in addition the following index:

## PHASE - Where REFSMMAT is desired

A1128          Set to 1 to compute REFSMMAT at beginning of the phase.

2.4.8 Primary Landing Area (PLA) Processor. - This processor
will be used to determine the deorbit maneuver ignition time and the time
to reverse bank angle required to achieve a target (longitude and latitude)
landing point which is normally located in a primary landing area. It has
the capability to simulate a maneuver at a fixed time or at a specified time
interval prior to the deorbit maneuver, the deorbit maneuver, and an entry
profile consisting of a specified lift vector orientation to a given g-load,
and then a positive bank angle followed by the negative of that bank angle to
drogue chute deployment. The processor also has the capability to simu-
late a zero and full lift entry profile.

The PLA processor is the only GEMMV processor that employs the
boundary value mode. The processor uses the iterative mode (PIT), prior
to the boundary mode, to determine the ignition time required to achieve a
longitude target landing point. This ignition time is then used by the
boundary value mode as an initial guess. If the ignition time to achieve a
longitude target is available, the PIT mode may be suppressed.



2-32
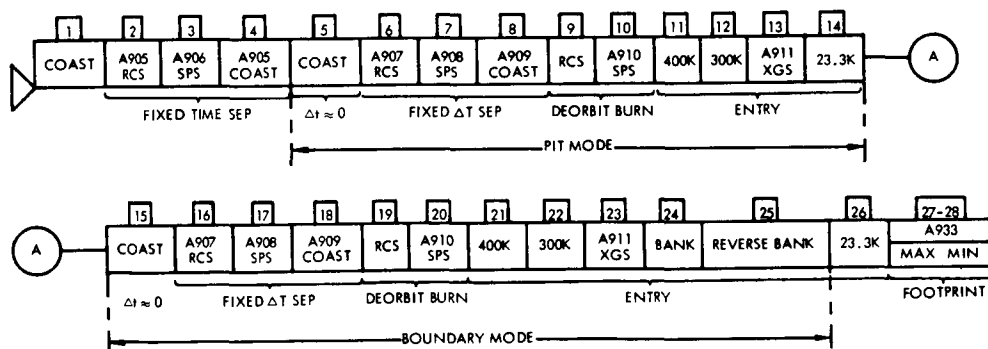
# PRIMARY LANDING AREA PROCESSOR

## (File 2; UNIVAC 1108)

A. Standard GEMMV input quantities for the PLA deck are listed below:

PHASE 1 - INITIAL COAST PHASE

### Initialization

| | |
|---|---|
| A905-11 | Flags to skip appropriate phases |
| A4871-3 | Vector identification |
| A368 | Revolution number |
| A93-5 | Lift-off time (hr, min, sec) (GMT) |
| A1138-40 | Vector time (hr, min, sec) (GMT) |
| A240-2 | Position coordinates (er) (X, Y, Z) |
| A248-50 | Velocity coordinates (er/hr) ($\dot{X}$, $\dot{Y}$, $\dot{Z}$) |
| A280 | Current weight (lb) |
| A1906 | Iteration flag (Already set to 0 on tape; set to 1 to suppress iteration.) |

### Fixed Time Maneuver

| | |
|---|---|
| A1148-50 | Time of RCS ignition (hr, min, sec) (g.e.t.) |
| A916 | Alignment option for maneuver |
| A917-9 | Body roll, pitch, and yaw angles, respectively which correspond to the alignment option |
| A931 | Guidance option for maneuver |
| A920-1 | Termination index and value, respectively, of RCS burn |
| A922-3 | Termination index and value, respectively, of SPS burn |

### Fixed Δt Maneuver

| | |
|---|---|
| A1148-50 | Time of RCS ignition (hr, min, sec) (g.e.t.) |
| A97 | Number of seconds after the fixed Δt maneuver initiation that phase 8 is to terminate (Set to a large number if a termination is input for phase 8.) |
| A916 | Alignment option for maneuver |

| | |
|---|---|
| A917-9 | Body roll, pitch, and yaw angles, respectively, which correspond to the alignment option |
| A931 | Guidance option for maneuver |
| A920-1 | Termination index and value, respectively, of RCS burn |
| A922-3 | Termination index and value, respectively, of SPS burn |

## Deorbit Maneuver

| | |
|---|---|
| A1148-50 | Time of RCS ignition (hr, min, sec) (g. e. t.) If a fixed time maneuver has been performed, set A1148-50 in phase 4 instead of phase 1. |
| A1018-26 | REFSMMAT stored row-wise (not necessary if REFSMMAT is computed at ignition) |
| A912 | Flag to compute REFSMMAT at deorbit ignition (Since already set to 1 on tape, set to 0 only if REFSMMAT is input.) |
| A913-5 | IMU roll, pitch, and yaw gimbal angles, respectively (necessary if REFSMMAT is computed or if alignment option 6 is specified) |
| A924 | Alignment option |
| A925-7 | Body roll, pitch, and yaw, respectively, which correspond to alignment option |
| A932 | Guidance option |
| A941-2 | Termination index and value, respectively, of RCS burn |
| A928-9 | Termination index and value, respectively, of SPS deorbit burn |

## Entry

| | |
|---|---|
| A901 | Lift vector orientation (bank angle) flown to a specified g-level (used only if A911 is set to 0) |
| A902 | Lift vector orientation (bank angle) flown from a specified g-level (if A911 = 0); if A911 = 1, see F. |
| A1902-3 | Longitude and latitude of the target |
| A911 | Set to 0 to execute the coast to X-g's phase. |
| A2907 | Set to specified g-level to initiate the entry mode (necessary only if A911 is set to 0). |

| A1172 | Entry lift multiplier to be used from a specified g-level (if A911 = 0) or from 300K feet (if A911 = 1) |
|---|---|
| A904 | Entry weight (lb) |
| A933 | Set to 0 if footprint is desired. |

PHASE 2 - FIXED TIME RCS SEPARATION

PHASE 3 - FIXED TIME SPS SEPARATION

PHASE 4 - COAST AFTER FIXED TIME SEPARATION

PHASE 5 - COAST TO DEORBIT BURN

PHASE 6 - RCS SEPARATION AT FIXED TIME PRIOR TO DEORBIT

PHASE 7 - SPS SEPARATION AT FIXED TIME PRIOR TO DEORBIT

PHASE 8 - COAST FROM SEPARATION TO DEORBIT

PHASE 9 - RCS ULLAGE PRIOR TO DEORBIT BURN

PHASE 10 - SPS DEORBIT BURN

PHASE 11 - COAST TO 400K FEET

PHASE 12 - COAST TO 300K FEET

PHASE 13 - COAST TO X-G POINT

PHASE 14 - COAST TO 23.3K FEET

PHASE 15 - COAST TO DEORBIT

| A655 | Set to 125000 only if A911 = 0, A901 = 180, and A2907 = 1. |
|---|---|

PHASE 16 - RCS SEPARATION AT FIXED TIME PRIOR TO DEORBIT

PHASE 17 - SPS SEPARATION AT FIXED TIME PRIOR TO DEORBIT

PHASE 18 - COAST FROM SEPARATION TO DEORBIT

PHASE 19 - RCS ULLAGE PRIOR TO DEORBIT BURN

PHASE 20 - SPS DEORBIT BURN

PHASE 21 - COAST TO 400K FEET

PHASE 22 - COAST TO 300K FEET

PHASE 23 - COAST TO X-G POINT

PHASE 24 - COAST TO BANK REVERSE

PHASE 25 - REVERSE BANK

PHASE 26 - COAST TO 23.3K FEET

PHASE 27 - MAXIMUM LIFT FOOTPRINT EXECUTION

PHASE 28 - MINIMUM LIFT FOOTPRINT EXECUTION

B.  If a navigation update is required at 12 minutes prior to deorbit ignition, set in addition the following indices:

PHASE 1 - INITIAL COAST

|  |  |
|---|---|
| A1148-50 | G.e.t. which is 12 minutes prior to deorbit ignition (hr, min, sec) (This should replace the RCS ignition time.) |
| A909 | Set to 0 so that the coast from separation to deorbit phase will be executed. (This phase will be used to execute the navigation update.) |

PHASE 8 - COAST FROM SEPARATION TO DEORBIT (PIT MODE)
 and
PHASE 18 - COAST FROM SEPARATION TO DEORBIT (BOUNDARY MODE)

|  |  |
|---|---|
| A649 | Set to 705 to terminate this coast 705 seconds prior to RCS ullage (for an RCS deorbit burn this value should be set to 720 seconds). |

PHASE 15 - COAST TO DEORBIT BURN

|  |  |
|---|---|
| A4270 | Set to 1 to execute navigation update at end of this phase. |

C.  If P-40 $\Delta$V's or P-30 $\Delta$V's and $\Delta$V residuals in the RCS control axes are to be input, set in addition the following indices:

PHASE 1 - INITIAL COAST PHASE

|  |  |
|---|---|
| A925 | Roll angle at ignition (LVLH) |

PHASE 9 - ULLAGE PRIOR TO DEORBIT BURN
 and
PHASE 19 - ULLAGE PRIOR TO DEORBIT BURN

|  |  |
|---|---|
| A996-8 | Residual $\Delta V_x$, $\Delta V_y$, $\Delta V_z$ input, respectively |
| A999-1001 | P-40 $\Delta V_x$, $\Delta V_y$, $\Delta V_z$ input, respectively |
| or A987-9 | P-30 $\Delta V_x$, $\Delta V_y$, $\Delta V_z$ input, respectively |

D.  If it is desired to iterate on $\Delta V$ while holding time of ignition fixed, set in addition the following indices:

PHASE 1 - INITIAL COAST PHASE

A1901          Set to 0 to call special iteration in PIT mode.

A147           Set to 6 to start iterative loop at beginning of SPS deorbit phase·

A148-9         Target index and value, respectively, for PIT mode

E.  If it is desired to suppress the PIT mode, set in addition the following index:

PHASE 1 - INITIAL COAST PHASE

A1906          Set to 1.

F.  If the coast to X-g point phase is not executed, set in addition the following indices:

PHASE 1 - INITIAL COAST PHASE

A902           Set to 0.

PHASE 15 - COAST TO DEORBIT

A902           Lift vector orientation (bank angle) flown from 300K feet

2.4.9 <u>Rolling Entry Processor.</u> - This processor will be used to determine the deorbit maneuver ignition time to achieve a target longitude or to determine the landing point, given the deorbit maneuver ignition time. The processor has the capability to simulate a maneuver at a fixed time or at a specified time interval prior to the deorbit maneuver, the deorbit maneuver and an entry profile consisting of a constant lift vector orientation to a given g-load, and then a constant roll rate about the atmospheric velocity vector to drogue chute deployment. Also, the processor has the capability to simulate a zero and full lift entry profile.
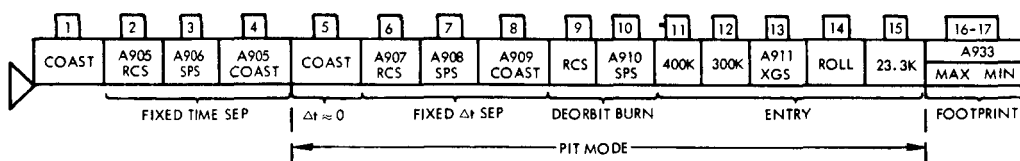
# ROLLING ENTRY PROCESSOR
## (File 3; UNIVAC 1108)

A. Standard GEMMV input quantities for the Rolling Entry deck are listed below:

## PHASE 1 - INITIAL COAST PHASE

### Initialization

| | |
|---|---|
| A905-11 | Flags to skip appropriate phases |
| A4871-3 | Vector identification |
| A368 | Revolution number |
| A93-5 | Lift-off time (hr, min, sec) (GMT) |
| A1138-40 | Vector time (hr, min, sec) (GMT) |
| A240-2 | Position coordinates (er) (X, Y, Z) |
| A248-50 | Velocity coordinates (er/hr) $(\dot{X}, \dot{Y}, \dot{Z})$ |
| A280 | Current weight (lb) |
| A1906 | Iteration flag (Already set to 0 on tape; set to 1 to suppress iteration.) |

### Fixed Time Maneuver

| | |
|---|---|
| A1148-50 | Time of RCS ignition (hr, min, sec) (g. e. t. ) |
| A916 | Alignment option for maneuver |
| A917-9 | Body roll, pitch, and yaw angles, respectively, which correspond to the alignment option |
| A931 | Guidance option for maneuver |
| A920-1 | Termination index and value, respectively, of RCS burn |
| A922-3 | Termination index and value, respectively, of SPS burn |

### Fixed Δt Maneuver

| | |
|---|---|
| A1148-50 | Time of RCS ignition (hr, min, sec) (g. e. t. ) |
| A97 | Number of seconds after the fixed Δt maneuver initiation that phase 8 is to terminate (Set to a large number if a termination is input for phase 8.) |
| A916 | Alignment option for maneuver |

| A917-9 | Body roll, pitch, and yaw angles, respectively, which correspond to the alignment option |
| A931 | Guidance option for maneuver |
| A920-1 | Termination index and value, respectively, of RCS burn |
| A922-3 | Termination index and value, respectively, of SPS burn |

## Deorbit Maneuver

| A1148-50 | Time of RCS ignition (hr, min, sec) (g. e. t. ) If a fixed time maneuver has been performed, set A1148-50 in phase 4 instead of phase 1. |
| A1018-26 | REFSMMAT stored row-wise (not necessary if REFSMMAT is computed at ignition) |
| A912 | Flag to compute REFSMMAT at deorbit ignition (Since already set to 1 on tape, set to 0 only if REFSMMAT is input.) |
| A913-5 | IMU roll, pitch, and yaw gimbal angles, respectively (necessary if REFSMMAT is computed or if alignment option 6 is specified) |
| A924 | Alignment option |
| A925-7 | Body roll, pitch, and yaw, respectively, which correspond to alignment option |
| A932 | Guidance option |
| A941-2 | Termination index and value, respectively, of RCS burn |
| A928-9 | Termination index and value, respectively, of SPS deorbit burn |

## Entry

| A901 | Lift vector orientation (bank angle) flown to a specified g-level (used only if A911 is set to 0) |
| A1902 | Longitude of target |
| A911 | Set to 0 to execute the coast to X-g's phase. |
| A2907 | Set to specified g-level to initiate the entry mode (necessary only if A911 is set to 0). |
| A1172 | Entry lift multiplier to be used from a specified g-level (if A911=0) or from 300K feet (if A911=1) |
| A904 | Entry weight (lb) |

A933                    Set to 0 if footprint is desired.

A2906                   Roll rate for entry phase (Set to 21.55544 on tape.)

PHASE 2 - FIXED TIME RCS SEPARATION

PHASE 3 - FIXED TIME SPS SEPARATION

PHASE 4 - COAST AFTER FIXED TIME SEPARATION

PHASE 5 - COAST TO DEORBIT BURN

PHASE 6 - RCS SEPARATION AT FIXED TIME PRIOR TO DEORBIT

PHASE 7 - SPS SEPARATION AT FIXED TIME PRIOR TO DEORBIT

PHASE 8 - COAST FROM SEPARATION TO DEORBIT

PHASE 9 - RCS ULLAGE PRIOR TO DEORBIT BURN

PHASE 10 - SPS DEORBIT BURN

PHASE 11 - COAST TO 400K FEET

PHASE 12 - COAST TO 300K FEET

PHASE 13 - COAST TO X-G POINT

PHASE 14 - 21.5-DEGREE ROLL RATE TO 75K

PHASE 15 - COAST TO 23.3K FEET

PHASE 16 - MAXIMUM LIFT FOOTPRINT EXECUTION

PHASE 17 - MINIMUM LIFT FOOTPRINT EXECUTION

B.  If a navigation update is required at 12 minutes prior to deorbit ignition, set in addition the following indices:

PHASE 1 - INITIAL COAST

A1148-50                G. e. t. which is 12 minutes prior to deorbit ignition (hr, min, sec) (This should replace the RCS ignition time.)

A909                    Set to 0 so that the coast from separation to deorbit phase will be executed.(This phase will be used to execute the navigation update.)

PHASE 5 - COAST TO DEORBIT BURN

A4270                   Set to 1 to execute navigation update.

PHASE 8 - COAST FROM SEPARATION TO DEORBIT

     A649               Set to 705 to terminate this coast 705 seconds prior to RCS ullage. (In the case of an RCS deorbit burn, this value should be set to 720 seconds. )

C.    If P-40 $\Delta V$'s and $\Delta V$ residuals in the RCS control axes are to be input, set in addition the following indices:

PHASE 1 - INITIAL COAST PHASE

     A925               Roll angle at ignition (LVLH)

PHASE 9 - ULLAGE PRIOR TO DEORBIT BURN

     A996-8          Residual $\Delta V_x$, $\Delta V_y$, $\Delta V_z$ input, respectively

     A999-1001     P-40 $\Delta V_x$, $\Delta V_y$, $\Delta V_z$ input, respectively
      or
     A987-9          P-30 $\Delta V_x$, $\Delta V_y$, $\Delta V_z$ input, respectively

D.    If it is desired to iterate on $\Delta V$ while holding time of ignition fixed, set in addition the following indices:

PHASE 1 - INITIAL COAST PHASE

     A1901            Set to 0 to call special iteration in PIT mode.

     A147               Set to 6 to start iterative loop at beginning of SPS deorbit phase.

     A148-9          Target index and value, respectively, for PIT mode

2.4.10 Hybrid Deorbit Processor. - This processor will be used to determine the hybrid deorbit ignition time required to achieve a target longitude. This processor has the capability to simulte a maneuver at a specified time, the hybrid deorbit maneuver, and an entry profile consisting of a constant lift vector orientation to a specified g-load, and then a constant bank angle to drogue chute deployment.

A hybrid deorbit is performed in two burns by using the SM and CM RCS thrusters to accomplish a fixed incremental velocity change with a constant inertial thrust vector orientation. This orientation is defined as follows. At the centroid of the hybrid deorbit burns, the thrust vector direction is opposite the geocentric local horizontal. After the CM/RCS burn, a 60-second coast allows time to perform CM/RCS separation and reorientation of the CM so that the effective thrust vector orientation remains constant.

The hybrid deorbit burn is simulated by the GEMMV program by employing the following logic. In phase 4 the vector is propagated to the SM/RCS burn time and the necessary quantities are input to calculate an analytic centroid of the combination burn. Phase 6 which is executed next, performs the centroid calculation, propagates the trajectory to the centroid, performs the necessary LVLH thrust vector attitude alignment, propagates backward to SM/RCS burn initiation holding the inertial attitude, and then integrates through the SM/RCS burn. The trajectory is then propagated to CM/RCS burn initiation in phase 8, and the CM/RCS burn is simulated in phase 9.



2-44
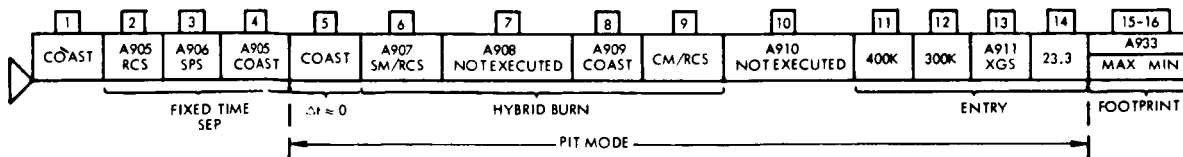
# HYBRID DEORBIT PROCESSOR

## (File 8; UNIVAC 1108)

A.  Standard GEMMV input quantities for the Hybrid Deorbit deck are listed below:

PHASE 1 - INITIAL COAST PHASE

### Initialization

| | |
|---|---|
| A905-11 | Flags to skip appropriate phases |
| A4871-3 | Vector identification |
| A368 | Revolution number |
| A93-5 | Lift-off time (hr, min, sec) (GMT) |
| A1138-40 | Vector time (hr, min, sec) (GMT) |
| A240-2 | Position coordinates (er) (X, Y, Z) |
| A248-50 | Velocity coordinates (er/hr) ($\dot{X}, \dot{Y}, \dot{Z}$) |
| A280 | Current weight (lb) |
| A1906 | Iteration flag (Already set to 0 on tape; set to 1 to suppress iteration.) |

### Hybrid Deorbit Maneuver

| | |
|---|---|
| A1148-50 | Time of RCS ignition (hr, min, sec) (g.e.t.) |
| A1018-26 | REFSMMAT stored row-wise (not necessary if REFSMMAT is computed at ignition) |
| A912 | Flag to compute REFSMMAT at deorbit ignition (Since already set to 1 on tape, set to 0 only if REFSMMAT is input.) |
| A913-5 | IMU roll, pitch, and yaw gimbal angles, respectively (necessary if REFSMMAT is computed or if alignment option 6 is specified) |
| A916 | Alignment option for hybrid maneuver (Set to 1 on tape.) |
| A917-9 | Body roll, pitch, and yaw angles, respectively, which correspond to the alignment option (Set to 0, 0, 180 on tape.) |
| A925 | CM body roll (Set to 180 on tape.) |
| A931 | Hybrid deorbit guidance option (Set to 6 on tape.) |
| A904 | CM preburn weight |
| A2923 | $\Delta V$ of SM RCS burn |

| A2924 | $\Delta T$ of coast between SM RCS and CM RCS burns (Set to 60 on tape.) |
|---|---|
| A2925 | $\Delta V$ of CM RCS burn |
| A901 | Lift vector orientation (bank angle) flown to a specified g-level (used only if A911 is set to 0) |
| A902 | Lift vector orientation (bank angle) flown from a specified g-level (if A911 = 0) or from 300K feet (if A911 = 1) |
| A1902 | Longitude of target |
| A911 | Set to 0 to execute the coast to X-g's phase. |
| A2907 | Set to specified g-level to initiate the entry mode (necessary only if A911 is set to 0). |
| A1172 | Entry lift multiplier to be used from a specified g-level (if A911 = 0) or from 300K feet (if A911 = 1) |
| A933 | Set to 0 if footprint is desired. |

PHASE 2 - ULLAGE MANEUVER PHASE

PHASE 3 - SPS DEORBIT BURN PHASE

PHASE 4 - COAST TO HYBRID DEORBIT BURN TIME PHASE

PHASE 5 - COAST TO SM RCS BURN PHASE

PHASE 6 - SM RCS BURN PHASE

PHASE 7 - NOT EXECUTED

PHASE 8 - COAST BETWEEN SM AND CM BURNS PHASE

PHASE 9 - CM RCS BURN PHASE

PHASE 10 - NOT EXECUTED

PHASE 11 - COAST TO 400K PHASE

PHASE 12 - COAST TO 300K PHASE

PHASE 13 - COAST TO X-G's PHASE

PHASE 14 - COAST TO 23.3K PHASE

PHASE 15 - MAXIMUM LIFT FOOTPRINT PHASE

PHASE 16 - MINIMUM LIFT FOOTPRINT PHASE

B. If an ullage or a partial SPS deorbit burn is to be performed prior to the hybrid deorbit, set in addition:

PHASE 1 - INITIAL COAST PHASE

| | |
|---|---|
| A1018-26 | REFSMMAT stored row-wise (not necessary if REFSMMAT if computed at ullage or SPS ignition) |
| A928-9 | Termination index and value, respectively, of SPS burn |
| A1148-50 | Time of ullage maneuver (hr, min, sec) (g. e. t. ) |

PHASE 2 - ULLAGE MANEUVER PHASE

| | |
|---|---|
| A1128 | Flag to compute REFSMMAT at ullage or SPS ignition (Since already set to 0 on tape; set to 1 only if REFSMMAT is to be input for ullage or SPS ignition.) |
| A1027-29 | IMU roll, pitch, and yaw gimbal angles, respectively, for ullage or SPS maneuver (necessary only if REFSMMAT is computed at ullage or SPS ignition) |
| A225 | Attitude option for ullage or SPS maneuver (Set to 4 on tape.) |
| A1118-20 | Roll, pitch, and yaw attitudes for ullage or SPS maneuver |
| A930 | Guidance option for ullage or SPS maneuver (Set to 4 on tape.) |
| A648 | Ullage termination index (Set to 123 on tape.) |
| A649 | Ullage termination value (Set to 15 on tape.) |

PHASE 4 - COAST TO HYBRID DEORBIT BURN TIME PHASE

| | |
|---|---|
| A1018-26 | REFSMMAT stored row-wise (necessary only if platform alignment has been performed after ullage or SPS maneuver) |
| A1148-50 | Time of SM RCS burn (hr, min, sec) (g. e. t. ) |

2.4.11 <u>FDO Orbit Digitals Processor.</u> - This processor will be used
to display, for any threshold time, the orbital parameters corresponding
to the threshold time as well as the associated apogee and perigee
parameters. The output will be in the format of the RTCC FDO Orbit
Digitals Display.

```
┌─┐      ┌─┐         ┌─┐            ┌─┐
│1│      │2│         │3│            │4│
├─┴──┬───┴──────────┬┴──────────────┬┴────────────┐
│COAST│COAST TO APOGEE│COAST TO APOGEE│CALL FDO ORBIT│
│     │OR PERIGEE     │OR PERIGEE     │DIGITALS      │
└─────┴───────────────┴───────────────┴──────────────┘
```
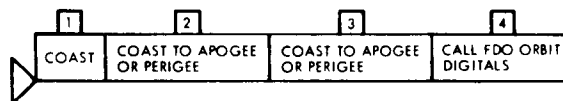
# FDO ORBIT DIGITALS PROCESSOR

## (Special FDO Orbit Digitals Deck; File 4; UNIVAC 1108)

Standard GEMMV input quantities for this processor are listed below:

PHASE 1 - INITIAL COAST PHASE

### Initialization

| | |
|---|---|
| A4871-3 | Vector identification |
| A368 | Revolution number |
| A93-5 | Lift-off time (hr, min, sec) (GMT) |
| A1138-40 | Vector time (hr, min, sec) (GMT) |
| A240-2 | Position coordinates (er) (X, Y, Z,) |
| A248-50 | Velocity coordinates (er/hr) ($\dot{X}, \dot{Y}, \dot{Z}$) |
| A280 | Current weight (lb) |

### Additional Updates

| | |
|---|---|
| A150* | Set to 1 only if the orbit digitals are to be based on the present vector. |
| A648-9 | Set to the proper termination index and value, respectively, if the orbit digitals are not to be based on the input vector. |

PHASE 2 - COAST TO APOGEE OR PERIGEE

| | |
|---|---|
| A86* | Set to 1 to save vector at beginning of phase for FDO Orbit Digitals Summary Sheet. |
| A648-9* | Termination index and value, respectively (Normally the index will be 315; flight-path angle and the value will be 0.) |

PHASE 3 - COAST TO APOGEE OR PERIGEE

PHASE 4 - SHORT DURATION COAST

| | |
|---|---|
| A648-9* | Termination index and value, respectively (Normally the index will be 123; phase time and the value will be 10.) |
| A142* | Set to 1 to call FDO orbit digitals summary sheet. |

PHASE 5 - RUN TERMINATION

A139*          Set to 1 to terminate run.


*These A-arrays have already been set to the correct value in the special
FDO orbit digitals on-line deck.

2.4.12 <u>Relative Motion Processor.</u> - This processor will be used to compute the relative motion of two vehicles and output the Relative Motion Digitals Display.

# RELATIVE MOTION PROCESSOR

## (File 4; UNIVAC 1108)

Standard GEMM V input quantities for the Relative Motion processor are listed below:

## PHASE 1 - INITIAL COAST PHASE

### Reference Vehicle Initialization

| | |
|---|---|
| A4871-3 | Vector identification |
| A368 | Revolution number |
| A93-5 | Lift-off time (hr, min, sec) (GMT) |
| A1138-40 | Vector time (hr, min, sec) (GMT) |
| A240-2 | Position coordinates (er) (X, Y, Z) |
| A248-50 | Velocity coordinates (er/hr) ($\dot{X}$, $\dot{Y}$, $\dot{Z}$) |
| A280 | Current weight (lb) |
| A293 | Cross sectional area of the reference vehicle |
| A1018-26 | REFSMMAT stored row-wise |

### Relative Vehicle Initialization

| | |
|---|---|
| A1368 | Revolution number |
| A2138-40 | Vector time (hr, min, sec) (GMT) |
| A1240-2 | Position coordinates (er) (X, Y, Z) |
| A1248-50 | Velocity coordinates (er/hr) ($\dot{X}$, $\dot{Y}$, $\dot{Z}$) |
| A1280 | Current weight (lb) |
| A1293 | Cross sectional area of the relative vehicle |

### Additional Updates

| | |
|---|---|
| A96 | Set to 1 if the relative vehicle vector time is prior to the time relative motion data is desired. |
| | Set to 2 if relative vehicle vector is after the time relative motion data is desired. |
| A117 | Set to 2 (highest vehicle capability being used). |
| A114 | Set to 2 (flag to call the WRITE 2 - Relative Motion subroutine). |

## Additional Updates (Continued)

A111          Set to 0 to specify constant integration step size.

A120          Set to desired integration step size in seconds (normally set to 1 in thrusting phases and 20 in coasting phases).

A4204         Set to N. (Output will be every N integration steps; this variable should be adjusted with A120 to achieve some specified constant output interval throughout the execution of the processor.)


Phase where relative motion output is not desired:

A4204         Set to 0. (This may be reset to N in any phase where relative motion output is again desired.)

2.4.13 <u>Ground Track, CMC or IU Navigation Update, and PAO Data Capabilities.</u> - If it is desired to produce a ground track, a navigation update, or PAO data with any of the GEMMV processors previously described, the following additional on-line inputs will be required.

A.   Additional GEMMV input quantities for ground track data are listed below:

Phases where ground track is to begin:

| | |
|---|---|
| A114 | Set to 5 to call WRITE 5 (ground track subroutine). |
| A111 | Set to 0 to specify constant integration. |
| A120 | Set to desired integration step size in seconds. (Normally set to 20 seconds in coasting phases and to 1 in thrusting phases.) |
| A4213 | Set to N. (Output will be every N integration steps; this variable will be adjusted with A120 to achieve some specified constant output frequency throughout processor execution.) |
| A4201 | Set to 0 to suppress WRITE 1 output. |

Phases where ground track is not desired:

| | |
|---|---|
| A4213 | Set to 0. (This may be reset to N in any phase where ground track is again desired.) |
| A4201 | Set to 100000 to activate WRITE 1. |

B.   Additional GEMMV input quantity for CMC navigation update data is listed below:

Phase where CMC navigation update is desired:

| | |
|---|---|
| A4270 | Set to 1 to call navigation update at end of a phase. |

C.   Additional GEMMV input quantities for IU navigation update data are listed below:

Phase where IU navigation update is desired:

| | |
|---|---|
| A152 | Set to 1 to call IU navigation update at end of phase. |
| A153 | Set to GMTL/O - GMTIUGRR (sec). |

D.   Additional GEMMV input quantities for PAO Data are listed below:

Phase where PAO Data is desired

| | |
|---|---|
| A154 | Set to 1 to call PAO summary sheet at end of phase. |
| A158 | PAO header (Starting in column 8, set to BCD and set column 12 to an 8.) |

# 3. OPERATING INSTRUCTIONS FOR THE GEMMV POST PROCESSORS

## 3.1 General

A GEMMV post processor is a program that is automatically executed after the GEMMV trajectory program has generated and stored the necessary input data on a tape. There are presently five post processors; the Guidance Optical Sighting Table (GOST), Radiation, Apollo Reentry Simulation (ARS), External Delta V and REFSMMAT Update, and Star Sighting Table (SST).

## 3.2 The GEMMV Post Processors

This section presents a brief description of the GEMMV post processors along with a listing of the control cards and the on-line input required to operate each processor.

3.2.1 <u>GOST Processor</u>. - This processor will primarily be used to verify the CM IMU stable member alignment made by using the onboard optical sighting equipment consisting of a scanning telescope, a sextant, and a boresight. By using a catalog of star and earth fixed landmark locations, this processor will calculate IMU gimbal angles, REFSMMATS, and the shaft and trunnion angles of the optical equipment. The processor has several options which may be used to determine the position of stars on the instrument reticles, to determine the necessary spacecraft attitude for viewing a ground target, to determine REFSMMAT, and to determine IMU gimbal angles.

Although the GOST processor can be run with any GEMMV processor, a special deck has been set up using File 4 of the mission data tape. The UNIVAC 1108 Data Processing System Control Cards are listed below:

| Column 1 | 4 | 8 | |
|---|---|---|---|
| $ JOB | | | NASA/MSC standard job card |
| *▽N | HDG | | Comment card |
| ▽ | ASG | A = XXXX | Program (PCF) tape number |
| ▽ | ASG | B = XXXX | Mission table tape number |
| ▽ | ASG | F = XXXX | Mission data tape number |
| ▽ | ASG | G, N, V | Scratch units on FASTRAND |
| ▽ | XQT | CUR | Execute the following instructions: |
| | TRW A, B, F, G, N, V | | Rewind units A, B, F, G, N, and V. |
| | IN A | | Read in first file of unit A. |
| | . <br> . <br> . <br> . | | Source language corrections (patches) |
| ▽N | XQT | GEMMV | Execute GEMMV program. |
| | . <br> . <br> . <br> . | | GEMMV updates |

| | |
|---|---|
| FILE | Last GEMMV data card |
| ▽    XQT  CUR | Execute the following instructions: |
| ERS | Erase last program from memory. |
| IN A | Read in file of tape A. |
| ▽N XQT  DGOST | Execute GOST program. |
| . | |
| . | GOST data cards |
| . | |
| . | |
| FILE | Last GOST data card |
| ▽EOF | Terminate the run. |

* ▽ indicates 7/8 overpunch in Column 1

# GOST PROCESSOR

## (Special GOST Deck; File 4; UNIVAC 1108)

A. The input quantities for the GEMMV part of the processor are the same for all GOST options (with two exceptions which are indicated). The standard input quantities are listed below:

PHASE 1 - COAST

| | |
|---|---|
| A4871-3 | Vector identification |
| A368 | Revolution number |
| A93-5 | Lift-off time (hr, min, sec) (GMT) |
| A1138-40 | Vector time (hr, min, sec) (GMT) |
| A240-2 | Position coordinates (er) (X, Y, Z) |
| A248-50 | Velocity coordinates (er/hr) ($\dot{X}$, $\dot{Y}$, $\dot{Z}$) |
| A280 | Current weight (lb) |
| A1148-50 | Time of GOST computation (hr, min, sec) (g. e. t. ) |
| A1027-9 | IMU roll, pitch, yaw gimbal angles, respectively (not necessary for GOST option 4 or 14 and 5 or 15) |
| A1018-26 | REFSMMAT stored row-wise (not necessary for GOST option 1 or 11) |
| A225[*] | Set to 6 to obtain correct attitude option. |
| A79[*] | Set to 2 to write 200 word record. |
| A80[*] | Set to 2 to call in GOST program from PCF tape. |

[*]These A-arrays have already been set to the correct value in the special GOST on-line deck.

B. The options of the GOST part of the processor as well as the card formats are listed below. Option 1 or 11 requires two input cards while option 5 or 15 requires four input cards. The remaining options each require only one card. All data punched in columns 10 through 70 must have decimal points. The GOST input cards are placed in the special GOST on-line deck just after the "XGT DGOST" card.

Option 1 or 11

| | |
|---|---|
| Input: | The identification of two stars and the sextant shaft and trunnion angles for each star |
| Compute: | REFSMMAT |

Option 2 or 12

    Input:               No inputs are needed for option 2 or 12.

    Compute:       The location of two stars which are in the scanning telescope field of view at a specified spacecraft attitude and IMU alignment. The two stars must satisfy the condition that one star lies on the R-line and the other star lies as close as possible to the M-line of the telescope recticle pattern.

Option 3 or 13

    Input:               The identification of two stars

    Compute:       The sextant shaft and trunnion angles for each of the input stars

Option 4 or 14

    Input:               The spacecraft LVLH roll and yaw angles plus the spacecraft pitch angle to the horizon

    Compute:       Gimbal angles and LVLH pitch angle

Option 5 or 15

    Input:               This option is the same as option 1 or 11 except the IMU gimbal angles are input in the GOST rather than the GEMMV program.

    Compute:       REFSMMAT

| Option Number | Columns | | | |
|---|---|---|---|---|
| | 1 - 2 | 10 - 25 | 30 - 45 | 50 - 65 |
| 1 or 11 | 11 | Star No. 1 | Shaft No. 1 | Trunnion No. 1 |
| | 11 | Star No. 2 | Shaft No. 2 | Trunnion No. 2 |
| 2 or 12 | 12 | * | * | * |
| 3 or 13 | 13 | Star No. 1 | Star No. 2 | |
| 4 or 14 | 14 | LVLH roll | ** | LVLH yaw |
| 5 or 15 | 15 | Star No. 1 | Shaft No. 1 | Trunnion No. 1 |
| | 15 | Star No. 2 | Shaft No. 2 | Trunnion No. 2 |
| | 15 | Roll GA No. 1 | Pitch GA No. 1 | Yaw GA No. 1 |
| | 15 | Roll GA No. 2 | Pitch GA No. 2 | Yaw GA No. 2 |

*Normally these columns should be blank. If non-blank, columns 10-25 should contain the roll gimbal angle, columns 30-45 should contain the pitch gimbal angle, and columns 50-65 should contain the yaw gimbal angle. If any of these angles are zero, they must be punched .00001.

**Normally a blank or 0. Either is recognized by the program as a 31.7-degree pitch between the X-body axis and line-of-sight to the horizon. Otherwise, the pitch angle (if other than 31.7 deg) should be input.

3.2.2 <u>Radiation Processor</u>.- This processor will be used to determine geomagnetic parameters and the radiation dose rates in the command module at given intervals along a trajectory. It will also be used to calculate REM dose in the command module over a particular portion of the Apollo 7 mission.

The UNIVAC 1108 Data Processing System Control Cards are listed below:

| Column 1 4 8 | | NASA/MSC standard job card |
|---|---|---|
| $ JOB | | |
| * ▽N HDG | | Comments |
| ▽ ASG | A = XXXX | Program (PCF) tape number |
| ▽ ASG | B = XXXX | Mission table tape number |
| ▽ ASG | F = XXXX | Mission data tape number |
| ▽ ASG | G, H, N, V | Scratch units on FASTRAND. |
| ▽ XQT | CUR | Execute the following instructions: |
| | TRW A,B,G,N,V,F,H | Rewind A, B, G, N, V, F, and H units. |
| | IN A | Read in first unit of tape A. |
| | • • • • • | Source language corrections |
| ▽ XQT | GEMMV | Start execution of the GEMMV program. |
| | • • • • • • | GEMMV data cards |
| FILE | | Last GEMMV data card |
| ▽ XQT | CUR | Execute the following instructions. |
| | ERS | Erase last program from memory. |
| | IN A | Read in next file of unit A. |

∇N  XQT  DECK1                     Start execution of radiation
                                  processor.

FILE                              Last radiation data card

∇EOF                              Terminate the run.

*∇ indicates 7/8 overpunch in Column 1

# RADIATION PROCESSOR

## (All GEMMV Files; UNIVAC 1108)

Additional GEMMV input quantities for the Radiation processor are listed below:

Phase where first radiation output is desired:

| | |
|---|---|
| A114 | Set to 3 to call WRITE 3 (radiation ephemeris) subroutine. |
| A80 | Set to 3 to call Radiation processor from PCF tape. |
| A111 | Set to 0 to specify constant integration interval. |
| A120 | Set to desired integration step size (sec). |
| A4207 | Set to N (output will be every N integration steps). |

Phase where last radiation output is desired:

| | |
|---|---|
| A4207 | Set to 0. |

3.2.3 <u>ARS Processor.</u> - The Apollo Reentry Simulation processor will be used to accept a state vector at 425,000 feet and compute the necessary guided entry profile to hit a target latitude and longitude. The state vector is generated by one of the GEMMV deorbit processors and is written into a 200-word record which interfaces with the ARS processor. Options exist within the processor to use one of six different entry modes which are described below.

## Mode 1 - Automatic Guidance and Navigation Control

In this steering mode, the ARS processor uses the CMC entry logic to compute the entry steering commands and to simulate the entry trajectory required to achieve the target landing point.

## Mode 2 - Open Loop Followed by Guidance and Navigation Control

In this entry mode, an initial bank angle is maintained from 400,000 feet to a specified g-level, at which time the CM is rolled to a second bank angle, designated as the backup bank angle. This attitude is maintained until the second g-level is reached. From this time until drogue chute deployment, the ARS processor uses the guidance and navigation control logic to compute the steering commands necessary to achieve the target landing point. This steering mode requires the input of an initial and backup bank angle and two g-levels.

## Mode 3 - Bank/Reverse-Bank

In this entry mode, which is used to compute backup guidance quantities, an initial bank angle is maintained from 400,000 feet to a specified g-level. It is then followed by a backup bank angle to a computed time to reverse bank, and the reverse bank angle is flown to drogue chute deployment. In this steering mode, the initial bank angle and g-level are input, and the backup bank angle and time to reverse bank are computed by the ARS processor.

## Mode 4 - Combined Bank/Reverse-Bank and Guidance and Navigation Control

This entry mode is the same as that described in the second steering mode with the exception that the processor computes the backup bank angle. The inputs consist of the intial bank angle and the two g-levels.

## Mode 5 - Rolling

In this entry, an initial bank angle is maintained from 400,000 feet to a specified g-level followed by a constant roll rate to drogue chute deployment. This mode requires the input of the initial bank angle, g-level, and roll rate.

## Mode 6 - Open Loop

This entry can either be a bank/reverse-bank as described in the third steering mode or a constant bank-angle entry from 400,000 feet to drogue chute deployment. The bank/reverse-bank option of this steering mode requires the input of the initial and backup bank angles, the g-level, and the time to reverse bank. A constant bank angle entry can be specified by inputting the value of the bank angle to be used as the initial bank angle and inputting the g-level and time to reverse bank as large values.

The UNIVAC 1108 Data Processing System Control Cards are listed below:

| Column 1 | 4 | 8 | |
|---|---|---|---|
| $ JOB | | | NASA/MSC standard job card |
| *▽N HDG | | | Comments |
| ▽ | ASG | A = XXXX | Program (PCF) tape number |
| ▽ | ASG | B = XXXX | Mission table tape number |
| ▽ | ASG | F = XXXX | Mission data tape number |
| ▽ | ASG | G, N, V | Scratch units on FASTRAND. |
| ▽ | XQT | CUR | Execute the following instructions: |
| | | TRW A, B, G, N, V, F | Rewind A, B, G, N, V, and F units. |
| | | IN A | Read in first file of tape A. |
| | | . | |
| | | . | Source language corrections |
| | | . | |
| | | . | |
| ▽N | XQT | GEMMV | Start execution of the GEMMV program. |

```
          .  ⎫
          .  ⎪
          .  ⎬              GEMMV data cards
          .  ⎪
          .  ⎪
          .  ⎭
    FILE                    Last GEMMV data card
    ∇XQT  CUR               Execute the following
                            instructions:
          ERS               Erase last program from
                            memory.
          IN A              Read in file from unit A.
    ∇N    SCD   DELK2M, DRBLK2
    ∇N    SCD   S12052M, S205B2
    ∇N    XQT   AS205/BLOCK2    Execute GEMMV program.
    IDFILE = 7
    ENDCAS                  Last ARS input card
    ∇EOF                    Terminate the run.
```

\* ∇ indicates 7/8 overpunch in Column 1

ARS PROCESSOR

(Files 1, 2, and 8; UNIVAC 1108)

Additional GEMMV input quantities for the ARS processor are listed below:

Phase 1

| | |
|---|---|
| A80 | Set to 1 to call ARS processor. |
| A2918 | Set to 1 for automatic guidance and navigation entry mode. |
| | Set to 2 for open loop guidance and navigation entry mode. |
| | Set to 3 for bank/reverse-bank entry mode. |
| | Set to 4 for combined combined bank/reverse-bank and guidance and navigation entry mode. |
| | Set to 5 for rolling entry mode. |
| | Set to 6 for open loop constant bank angle or bank reverse entry mode. |
| A2914 | G-level to initiate backup guidance mode (Set when A2918 equals a 2 or 4.) |
| A2915 | Time to reverse bank in total seconds (g. e. t.) (Set when A2918 equals 6.) |

Coast to 400K Phase

| | |
|---|---|
| A79 | Set to 2 to write 200-word record at end of phase. |
| A649 | Set to 425,000.(Terminate on an altitude of 425,000 ft) |

3.2.4 <u>External Delta V and REFSMMAT Update Processor</u>. - This processor will be used to convert the REFSMMAT and external delta V quantities calculated by the GEMMV program to the CMC uplink format.

The UNIVAC 1108 Data Processing System Control Cards are listed below:

| Column 1 | 4 | 8 | |
|---|---|---|---|
| $ JOB | | | NASA/MSC standard job card |
| * ∇N | HDG | | Comments |
| ∇ | ASG | A = XXXX | Program (PCF) tape number |
| ∇ | ASG | B = XXXX | Mission table tape number |
| ∇ | ASG | F = XXXX | Mission data tape number |
| ∇ | ASG | G, N, V | Scratch units on FASTRAND. |
| ∇ | XQT | CUR | Execute the following instructions: |
| | | TRW A, B, F, G, N, V | Rewind units A, B, F, G, N, and V. |
| | | IN A | Read in first file of tape A. |
| | | . | |
| | | . | Source language corrections (patches) |
| | | . | |
| | | . | |
| ∇N | XQT | GEMMV | Execute GEMMV program. |
| | | . | |
| | | . | GEMMV updates |
| | | . | |
| | | . | |
| FILE | | | Last GEMMV data card |
| ∇ | XQT | CUR | Execute the following instructions: |
| | | ERS | Erase last program from memory. |
| | | IN A | Read in file of tape A. |
| ∇ N | XQT | DSKYUP | Execute DSKYUP program. |
| FILE | | | Last DSKYUP data card |
| ∇EOF | | | Terminate the run. |

*Indicates 7/8 overpunch in Column 1

# EXTERNAL DELTA V AND REFSMMAT UPDATE PROCESSOR

## (All GEMMV Files; UNIVAC 1108)

Additional GEMMV input quantities for the External Delta V and REFSMMAT Update processor:

Phase where external delta V or REFSMMAT update output is desired:

| | |
|---|---|
| A80 | Set to 6 to call the External Delta V and REFSMMAT Update processor. |
| A79 | Set to 2 to write the 200 word record. |

3.2.5 <u>Star Sighting Table (SST) Processor</u>. - This processor will be used to compute ground and celestial sighting data for selected targets. It has two modes of operation. Mode 1 is fixed optics; i.e., where the sextant shaft and trunnion angles are specified and IMU gimbal angles are calculated at the time of arrival to a particular lime of sight. Mode 2 is movable optics; i.e., where the IMU gimbal angles are specified and the sextant shaft and trunnion angles are calculated at the time of arrival to a particular line of sight. REFSMMAT must also be specified in the GEMMV portion for both modes.

The line of sight to a ground target is specified by the elevation angle (depression angle from the local horizontal) and the target itself is specified by I.D., height above a Fisher Ellipsoid, and geodetic latitude and longitude. For the ground target option, the processor calculates gimbal angles or sextant angles (depending on the mode), time of arrival to the line of sight, and time and longitude of the satellite's closest approach to the target.

The SST processor uses the input celestial target I.D. to look up in a star catalog the mean Besselian right ascension and declination of the celestial target. The line of sight is defined at the first time a line from the spacecraft to a celestial target that does not pass through the earth or atmosphere. The time this line of sight occurs, the corresponding sub-satellite longitude, the minimum central angle, and the time this central angle occurs are calculated by the celestial target option of the SST processor. For the celestial target option, the processor calculates gimbal angles or sextant angles (depending on the mode), the time and subsatellite longitude that corresponds to the line of sight, the minimum central angle between the celestial target and spacecraft, and the time the minimum occurs.

The UNIVAC 1108 Data Processing System Control Cards are listed below:

Column 1    4    8

$ JOB                           NASA/MSC standard job card

* ∇ N   HDG                     Comments

∇       ASG   A = XXXX          Program (PCF) tape number

∇       ASG   B = XXXX          Mission table tape number

| | | | |
|---|---|---|---|
| ▽ | ASG | F = XXXX | Mission data tape number |
| ▽ | ASG | G, N, V | Scratch units on FASTRAND. |
| ▽ | ASQ | Q = Q | Ephemeris tape unit |
| ▽ | XQT | CUR | Execute the following instructions: |
| | | TRW A,B,F,G,N,V,Q | Rewind units A, B, F, G, N, V, and Q |
| | | IN A | Read in first file of tape A. |
| | | . | |
| | | . | Source language corrections (patches) |
| | | . | |
| | | . | |
| ▽N | XQT | GEMMV | Execute GEMMV program. |
| | | . | |
| | | . | GEMMV updates |
| | | . | |
| | | . | |
| | FILE | | Last GEMMV data card |
| ▽ | XQT | CUR | Execute the following instructions: |
| | | ERS | Erase last program from memory. |
| | | IN A | Read in file of tape A. |
| ▽N | XQT | SST | Execute SST processor. |
| | | . | |
| | | . | SST data cards |
| | | . | |
| | | . | |
| | FILE | | Last SST data card |
| | ▽EOF | | Terminate the run. |

*▽ indicates 7/8 overpunch in Column 1

# STAR SIGHTING TABLE PROCESSOR

## (Any File; UNIVAC 1108)

A. Additional GEMMV input quantities for the SST processor are listed below:

Phases where SST data is required:

| | |
|---|---|
| A114 | Set to 6 to call the WRITE 6 subroutine (used to write an ephemeris tape). |
| A80 | Set to 7 to call the SST processor from the PCF tape. |
| A111 | Set to 0 to specify constant integration. |
| A120 | Set to desired integration step size (sec). |
| A4216 | Set to N. (Output will be every N integration steps.) |

Phases where SST data is not required:

| | |
|---|---|
| A4216 | Set to 0. (This may be reset to N in any phase where the ephemeris generation is again required.) |

B. Input quantities for the SST processor are listed below:

Option 1 - Fixed optics, celestial target

Card 1

Columns

| | |
|---|---|
| 1 | Set to 1 (processor option flag). |
| 10-12 | Revolution on the ephemeris tape produced by the GEMMV program to be searched for sighting data. Set to 0 to input a start and stop time rather than a revolution number (I3). |
| 14-16 | Star number (I3)* |
| 20-29 | Shaft angle (deg) (E10) |
| 30-39 | Trunnion angle (deg) (E10) |
| 40-42 | Hours of start time (g.e.t.) (I3) |
| 44-45 | Minutes of start time (g.e.t.) (I2) |

| | |
|---|---|
| 47-51 | Seconds of start time (g.e.t.) (E5) |
| 53-55 | Hours of stop time (g.e.t.) (I3) |
| 57-58 | Minutes of stop time (g.e.t.) (I2) |
| 60-64 | Seconds of stop time (g.e.t.) (E5) |

Option 2 - Moveable optics, celestial target

Card 1

Columns

| | |
|---|---|
| 1 | Set to 2 (processor option flag). |
| 10-12 | Revolution on the ephemeris tape produced by the GEMM V program to be searched for sighting data. Set to 0 to input a start and stop time rather than a revolution number (I3). |
| 14-16 | Star number (I3)* |
| 40-42 | Hours of start time (g.e.t.) (I3) |
| 44-45 | Minutes of start time (g.e.t.) (I2) |
| 47-51 | Seconds of start time (g.e.t.) (E5) |
| 53-55 | Hours of stop time (g.e.t.) (I3) |
| 57-58 | Minutes of stop time (g.e.t.) (I2) |
| 60-64 | Seconds of stop time (g.e.t.) (E5) |

Card 2

Columns

| | |
|---|---|
| 1-10 | Roll gimbal angle (E10) |
| 11-20 | Pitch gimbal angle (E10) |
| 21-30 | Yaw gimbal angle (E10) |

Option 3 - Fixed optics, ground target

Card 1

Columns

| | |
|---|---|
| 1 | Set to 3 (processor option flag). |
| 10-12 | Revolution on the ephemeris tape produced by the GEMM V program to be searched for sighting data. Set to 0 to input a start and stop time rather than a revolution number (I3). |
| 20-29 | Shaft angle (deg) (E10) |

| 30-39 | Trunnion angle (deg) (E10) |
| 40-42 | Hours of start time (g.e.t.) (I3) |
| 44-45 | Minutes of start time (g.e.t.) (I2) |
| 47-51 | Seconds of start time (g.e.t.) (E5) |
| 53-55 | Hours of stop time (g.e.t.) (I3) |
| 57-58 | Minutes of stop time (g.e.t.) (I2) |
| 60-64 | Seconds of stop time (g.e.t.) (E5) |

Card 2

Columns

| 1-12 | Landmark I.D. (A12) |
| 21-30 | Latitude (deg) (E10) |
| 31-40 | Longitude (deg) (E10) |
| 41-50 | Altitude (ft) (E10) |
| 51-60 | Desired elevation angle (deg) (E10) |

Option 4 - Moveable optics, ground target

Card 1

Columns

| 1 | Set to 4 (processor option flag). |
| 10-12 | Revolution on the ephemeris tape produced by the GEMMV program to be searched for sighting data. Set to 0 to input a start and stop time rather than a revolution number (I3). |
| 40-42 | Hours of start time (g.e.t.) (I3) |
| 44-45 | Minutes of start time (g.e.t.) (I2) |
| 47-51 | Seconds of start time (g.e.t.) (E5) |
| 53-55 | Hours of stop time (g.e.t.) (I3) |
| 57-58 | Minutes of stop time (g.e.t.) (I2) |
| 60-64 | Seconds of stop time (g.e.t.) (E5) |

Card 2

Columns

1-12    Landmark I. D. (A12)

21-30    Latitude (deg) (E10)

31-40    Longitude (deg) (E10)

41-50    Altitude (ft) (E10)

51-60    Desired elevation angle (deg) (E10)


*If it is required to input the declination and right ascension of a celestial target, then set star number to 0 and input as follows:

Card 2

Columns

1-10    Declination (deg) (E10)

11-21    Declination (min) (E10)

21-30    Declination (sec) (E10)

31-40    Right ascension (deg) (E10)

41-50    Right ascension (min) (E10)

51-60    Right ascension (sec) (E10)

# 4. OPERATING INSTRUCTIONS FOR THE WORK SCHEDULE PROCESSOR

## 4.1 General

This section presents the on-line inputs required for execution of the Work Schedule processor, a brief description of the processor, the tape setup, and the control cards used in conjunction with the processor.

## 4.2 Program Description

The Work Schedule processor is divided into three separate modules. Module I (any GEMMV processor) is used to generate an ephemeris tape which becomes the input to the next module. The ephemeris tape contains all the pertinent orbit and maneuver data over a specified time interval. Module II accepts the ephemeris tape and generates that ephemeris and tracking data requested and outputs them on the appropriate summary sheets. The data which can be obtained from Module II includes the following: spacecraft daylight-darkness, spacecraft moon sighting, computed events, landmark sighting, spacecraft star sighting, closest approach, and pointing data. These data are also saved on an interface tape which serves as the input to Module III. The processor may be terminated at this point if only the ephemeris and tracking data are desired. The processor output then consists of the ephemeris and tracking data summary sheets.

The execution of Module III is performed when the work schedule is desired. It sorts the information contained on the interface tape and input event cards and generates a plot tape which is delivered to the DD80 where a film of the work schedule is produced. Hard copies of the film are made after the film is returned to Building 45.

## 4.3 Tape Setup for the UNIVAC 1108 Data Processing System

| Tape Unit | Tape Description |
|-----------|------------------|
| A | Program (PCF) tape |
| B | Mission table tape |
| F | Mission data tape |
| I | $EPHEM tape (system) |
| S | Plot package (system) |
| T | Sort package (system) |
| Q | Ephemeris tape generated by Module I |
| R | Data tape generated by Module II |
| J | Sorted tape for use by Module III |
| G | Scratch tape |

|   |   |
|---|---|
| N | Scratch tape |
| K | Scratch tape |

## 4.4  Control Card Listing for the UNIVAC 1108 Data Processing System

### 4.4.1  Module I

Column  1    4    8

| | | | |
|---|---|---|---|
| $ | JOB | | |
| *▽N | HDG | | Comments |
| ▽ | ASG | A = XXXX | PCF tape |
| ▽ | ASG | B = XXXX | Table tape |
| ▽ | ASG | F = XXXX | Data tape |
| ▽ | ASG | I = $EPHEM | Sun, moon, and star ephemerides |
| ▽ | ASG | S = $PLOTS | Plot package (System) |
| ▽ | ASG | T = $SORT$ | Sort package (System) |
| ▽ | ASG | Q | Ephemeris tape generated by Module I |
| ▽ | ASG | R | Data tape generated by Module II |
| ▽ | ASG | J | Sorted tape for use by Module III |
| ▽ | ASG | G, N, K | Scratch units on FASTRAND |
| ▽ | XQT | CUR | Execute following instructions: |
| | TRW | A,B,F,G,J,N,Q,R,I,S,T,K | Rewind all listed tapes. |
| | IN A | | Read in first file of unit A. |
| | XQT | GEMMV | Execute the GEMMV program. |
| | . | | |
| | . | | |
| | . | | Module I data cards (any standard GEMMV on-line deck) |
| | . | | |
| | . | | |
| | . | | |
| | FILE | | End of input for Module I |

### 4.4.2 Module II

```
Column  1       4       8

        ▽       XQT     CUR     Execute the following instructions:
                ERS             Erase last program from memory.
                IN A            Read in file of unit A
        ▽       XQT     MAIN    Execute Module II
        .  ⎫
        .  ⎪
        .  ⎬                    Module II data card
        .  ⎪
        .  ⎭
        FILE 5                  Call Module III.
```

### 4.4.3 Module III

```
Column  1       4       8

        ▽       XQT     CUR     Execute the following instructions
                ERS             Erase the last program from memory
                IN A            Read in file of unit A
                IN S            Read in file of unit S
                IN T            Read in file of unit T
        ▽       XQT     MAIN3   Execute Module III
        .  ⎫
        .  ⎪
        .  ⎪
        .  ⎬                    Module III data cards
        .  ⎪
        .  ⎪
        .  ⎭
        6                       Terminate the input for Module III.
        ▽EOF                    Terminate the deck.
```

### 4.5 Inputs to the Work Schedule Processor

4.5.1 Inputs to Module I. - The following inputs are in addition to any of the standard GEMMV input quantities as described in Section 2:

PHASE 1

A80                 Set to 4 to call Module II after GEMMV termination.

4-3

| A114 | Set to 4 to call WRITE 4 subroutine (used to generate the tapes for Module II). |
|---|---|
| A102 | Set to 20 (output unit for WRITE 4). |
| A111 | Set to 0 to specify constant integration. |
| A120 | Set to desired integration interval (sec). |
| A138 | Set to day of year of lift-off. |

Phase where work schedule output is desired:

| A4210 | Set to N (output will be every N integration steps; A4210 is usually adjusted so that WRITE 4 will output approximately every 20 seconds of orbit propagation time; e. g., if A120 is set to 10 sec, then A4210 would be set to 2. ) |
|---|---|

Phase after last work schedule output is desired:

| A648-9 | Termination index and value, respectively (Normally the index should be A123 phase time, and the value should be 10 sec) |
|---|---|
| A102 | Set to -20 (writes an EOF on tape unit 20). |

The last phase in the deck should have A139 set to 1 to terminate the run.

### 4.5.2 Inputs to Module II

Card 1 - This card is used to specify the types of data to be processed (I3).

Columns

| 2-4 | Number of radar stations to be processed (presently 29) |
|---|---|
| 6-8 | Number of landmarks to be processed (type I cards) |
| 10-12 | Number of stars to be processed (type II cards) |
| 14-16 | Number of pointing targets to be processed (type III cards) |
| 18-20 | Number of closest approach targets (type IV cards) |
| 22-24 | Flag for daylight-darkness computation (If = 0, do not compute; if greater than 0, compute.) |
| 26-28 | Flag for moon sighting computation (If = 0, do not compute; if greater than 0, compute.) |
| 30-32 | Flag to compute events (apogee, perigee, ascending mode, revolution number, etc. ) If = 0, events will not be computed; if greater than 0, they will be computed. |

| | |
|---|---|
| 34-36 | Number of active vehicles in the GEMMV run |
| 38-40 | Minimum elevation angle for radar stations (0-90 degrees) |
| 42-44 | Angle for landmark sightings (0-90 degrees) |
| 46-48 | Flag to print altitude as a computed event. The number input in this field is the $\Delta t$ in minutes at which altitude will be printed (i.e., a 15 will request altitude to be printed every 15 minutes over the interval specified in the following six fields). |
| 50-52 | Hr (g. e. t. ) |
| 54-56 | Min (g. e. t. ) — Start altitude print (if 46-48 greater than 0). |
| 58-60 | Sec (g. e. t. ) |
| 62-64 | Hr (g. e. t. ) |
| 66-68 | Min (g. e. t. ) — Stop altitude print (if 46-48 greater than 0). |
| 70-72 | Sec (g. e. t. ) |

Card 2 - If columns 2-64 of this card are blank, the entire trajectory generated will be processed. Otherwise columns 2-16 specify start time for vehicle 1, columns 18-32 specify stop time for vehicle 1; likewise, columns 34-48 and 50-64 specify start and stop times for vehicle 2.

Columns

| | |
|---|---|
| 2-4 | Day (I3) |
| 6-8 | Hr (I3) — Start time vehicle 1 (g.e.t.) |
| 10-12 | Min (I3) |
| 14-16 | Sec (I3) |
| 18-20 | Day (I3) |
| 22-24 | Hr (I3) — Stop time vehicle 1 (g.e.t.) |
| 26-28 | Min (I3) |
| 30-32 | Sec (I3) |
| 34-36 | Day (I3) |
| 38-40 | Hr (I3) — Start time vehicle 2 (g.e.t.) |
| 42-44 | Min (I3) |
| 46-48 | Sec (I3) |
| 50-52 | Day (I3) |
| 54-56 | Hr (I3) — Stop time vehicle 2 (g.e.t.) |
| 58-60 | Min (I3) |
| 62-64 | Sec (I3) |
| 66-75 | Minimum eccentricity for which apogee and perigee will be printed (E10) |

Data Cards - If used, these cards must follow Card 2.

Type I Cards - These cards are used only if landmark data are to be processed. Any number of cards may be input, but they must input in ascending order (I3).

Columns

| | |
|---|---|
| 2-4 | I. D. number of landmark 1 |
| 6-8 | I. D. number of landmark 2 |
| 10-12 | I. D. number of landmark 3 |

. .    . . . . . . . .

. .    . . . . . . . .

Type II Cards - These cards are used only if star data are to be processed. Any number of cards may be used, but they must be input in ascending order (I3).

Columns

| | |
|---|---|
| 2-4 | I. D. number of star 1 |
| 6-8 | I. D. number of star 2 |
| 10-12 | I. D. number of star 3 |

. .    . . . . . . . .

. .    . . . . . . . .

Type III Cards - These cards are used only if pointing data are to be processed. Each target must be specified on a separate card. Up to 5 pointing target cards may be processed.

Columns

| | |
|---|---|
| 1-12 | I. D. of pointing target (A12) |
| 14-23 | Latitude of target (deg) (E10) |
| 25-34 | Longitude of target (deg) (E10) |
| 36-44 | Altitude of target (ft) (E8) |
| 45-48 | Elevation angle desired (deg) (E4) |
| 50-51 | Flag for the type of range (A2) Set to S- for slant range (used for WSRR test) Leave blank for ground range |

<u>Type IV Cards</u> - These cards are used only if "closest approach target" data are to be processed. Each target must be specified on a separate card. Up to five target cards may be processed.

Columns

| | |
|---|---|
| 1-12 | I. D. of target (A12) |
| 15-23 | Latitude of target (deg) (E9) |
| 25-34 | Longitude of target (deg) (E10) |
| 40-49 | Altitude of target (ft) (E10) |

### 4. 5. 3  Inputs to Module III

Card 1 - This card determines if the plot tape from Module II is to be sorted.

Columns

| | |
|---|---|
| 1-4 | SORT = Sort Module II tape. |
| | Blank = Do not sort Module II tape. |

Card 2 - This card determines the column arrangement, time scales desired, mission name, and current date. Each column on the card corresponds to the same numbered columns of the plot. To delete an option from the plot, punch an 8 in the respective column.

Columns

| | |
|---|---|
| 1 | Set to 0 for GET (I1). |
| | Set to 1 for RET (I1). |
| | Set to 2 for GMT (I1). |
| | Set to 3 for EST (I1). |
| 2 | Same input as column 1 (I1) |
| 3 | Same input as column 1 (I1) |
| 4 | Set to 4 to specify radar output (I1) |
| 5 | Set to 5 to specify sunrise/sunset in column 5 (I1) |
| 6 | Set to 6 to specify moonrise/moonset in column 6 (I1) |
| 7 | Set to 7 to specify computed events in column 7 (I1) |
| 10 | Desired time scale (I1) |
| | 1 = 2 hours |
| | 2 = 15 minutes |
| | 3 = 1 hour |
| | 4 = 30 minutes |
| | 5 = 42 minutes |

| | |
|---|---|
| 13-30 | Mission name (A18) |
| 33-44 | Current date (A12) |

Card 3 - This card determines the vehicle, time range, and vehicle name of the plot.

Columns

| | | |
|---|---|---|
| 1-2 | Number of vehicle (1 or 2) to be plotted (I2) | |
| 5-6 | Day (I2) | Start time of plot. If zeroes are input, plot starts at beginning of tape (g. e. t. ) |
| 8-9 | Hr (I2) | |
| 11-12 | Min (I2) | |
| 14-15 | Sec (I2) | |
| 17-18 | Day (I2) | Stop time of plot. If zeroes are input, plot stops at end of tape (g. e. t. ) |
| 20-21 | Hr (I2) | |
| 23-24 | Min (I2) | |
| 26-27 | Sec (I2) | |
| 33-38 | Vehicle name (A6) | |

Card 4 - These cards are used to input events at the time they occur. Use one card per event, and as many cards as are necessary.

Columns

| | | |
|---|---|---|
| 1-2 | Set to 11 to indicate input event card (I2). | |
| 5-6 | Day (I2) | Time of input event in g. e. t. |
| 7-9 | Hr (I3) | |
| 11-12 | Min (I2) | |
| 14-15 | Sec (I2) | |
| 20-80 | Input statement (A42) | |

If another vehicle is desired or if another time range is desired for the same vehicle, another Card 3 is input with the same format as described above. Following this card will be the input events associated with this vehicle or time range.

If another column arrangement or another time scale is desired, the following card is input:

Card 5

Columns

| | |
|---|---|
| 1-2 | Set to 3 to indicate that a card 2 is to be read in next (I2). |

Following this card, another Card 2 is input along with the Cards 3 and 4 associated with it.

Card 6

Column

2               Set to 6 to indicate end of run.   Must always be the last card in Module III (I1).

4. 6  Inputs for the Predicted Site Acquisition Table (PSAT) Option

In order to generate PSAT data, Modules I and II only are used. Module I input is identical to that described in Section 4. 4. 1, and Module II is identical to the inputs described in Section 4. 4. 2, except for the following:

Card 1

Columns

2-4             Set to 29 if all 29 stations are to be processed (I3).

34-36           1 or 2 depending on the number of vehicles which are to be processed (I3)

38-40           Minimum elevation angle (I3)

Card 2

Columns

1-64            Blank if the entire trajectory is to be processed for PSAT.

If portions of the generated trajectory are to be processed, set the following:

| 2-4   | Day (I3) | |
|-------|----------|---|
| 6-8   | Hr (I3)  | Start time |
| 10-12 | Min (I3) | vehicle 1 (g. e. t. ) |
| 14-16 | Sec (I3) | |
| 18-20 | Day (I3) | |
| 22-24 | Hr (I3)  | Stop time |
| 26-28 | Min (I3) | vehicle 1 (g. e. t. ) |
| 30-32 | Sec (I3) | |

| | | |
|---|---|---|
| 34-36 | Day (I3) | |
| 38-40 | Hr (I3) | Start time |
| 42-44 | Min (I3) | vehicle 2 (g. e. t. ) |
| 46-48 | Sec (I3) | |
| 50-52 | Day (I3) | |
| 54-56 | Hr (I3) | Stop time |
| 58-60 | Min (I3) | vehicle 2 (g. e. t. ) |
| 62-64 | Sec (I3) | |
| 66-75 | Minimum eccentricity for which apogee and perigee will be printed (E10) | |

Replace the FILE 5 card in Module II with a FILE card followed by an ∇EOF card.

# 5. OPERATING INSTRUCTIONS FOR THE RTACF MONITOR SYSTEM PROCESSORS

## 5.1 General

This section presents the on-line inputs required for executing the Apollo 7 Monitor System processors; a brief discussion of the purpose of each processor; and the tape setups and control card listings required to operate this group of processors on the IBM 7094 and UNIVAC 1108 data systems.

## 5.2 Tape Setup for the IBM 7094 Data Processing System

| Tape Unit | Tape Description |
|-----------|------------------|
| A2 | Monitor system data tape |
| A3 | Off-line output tape |
| B1 | Monitor system program tape |
| B5 | ARRS data tape |
| A5 | Updated ARRS data tape |

## 5.3 Tape Setup for the UNIVAC 1108 Data Processing System

| Tape Unit | Tape Description |
|-----------|------------------|
| A | Monitor program tape |
| B | Mission data tape |

## 5.4 Control Card Listing for the IBM 7094 Data Processing System

There are no control cards required to execute Monitor System processors on the IBM 7094 data processing system.

## 5.5 Control Card Listing for the UNIVAC 1108 Data Processing System

| Column 1 | 4 | 8 | |
|----------|---|---|---|
| $ JOB | | | NASA/MSC standard job card |
| ▽N HDG | | | Comments |
| ▽ | ASG | A = XXXX | Program (PCF) tape number |
| ▽ | ASG | B = XXXX | Mission monitor data tape number |
| ▽ | XQT | CUR | Execute the following instructions: |
| | TRW | A, B | Rewind units A, B. |
| | IN | A | Read in first file of tape A. |

```
∇   XQT  OLPROC        Execute the mission monitor
                       (PROCES) program.

        •   ⎤
        •   ⎟
        •   ⎟
        •   ⎬             Mission monitor data cards
        •   ⎟
        •   ⎟
        •   ⎦

∇   EOF                Terminate the run.
```

## 5.6  Inputs to the Monitor System Processors

This section presents the inputs required to operate the Apollo 7 mission Monitor System processors along with a brief description of each processor.  Except for the first processor which uses some GEMMV type inputs, all the inputs have field specifications indicated in parentheses after the card, if all the fields are the same, or after the variable, if there are different fields on a card.  Since the indicated field specifications are not in strict accordance with the processor's FORTRAN format statement, a brief explanation is given.

A field specification consists of the following:

- A letter (I, E, O, A) to designate the kind of input the processor will expect

- A number to designate the maximum number of columns allowed for each input

The letter I specifies integer input, right justified, and no decimal point.  The letter E specified decimal input, left justified, and a decimal point.  The letter O specifies octal input, left justified, and no decimal point.  The letter A specifies letters, digits, punctuations, and blank input, left justified.

5.6.1 <u>Checkout Monitor Processor.</u> - This processor will be used to generate the RTCC Checkout Monitor display, using either a S-IVB telemetry, a CSM telemetry, or a RTCC tracking vector. It will also be used to store these vectors in the proper input format for the Apollo Real-Time Rendezvous Support and GEMMV programs.

## CHECKOUT MONITOR PROCESSOR

### (IBM 7094 and UNIVAC 1108)

#### On-Line Card Input

| | |
|---|---|
| Card 1 | File number |
| Columns | |
| 1-2 | 01 |
| Cards 2 - TRA Card | Input is the same format as the GEMMV program and the cards may be in any order. |
| A4871-3 | Vector identification |
| A368 | Revolution number |
| A93-5 | Lift-off time (hr, min, sec) (GMT) |
| A1138-40 | Vector time (hr, min, sec) (GMT) |
| A240-2 | Position coordinates (ft, km, or er) (X, Y, Z) |
| A248-50 | Velocity coordinates (ft/sec, m/sec, or er/hr) ($\dot{X}$, $\dot{Y}$, $\dot{Z}$) |
| A280 | Current weight (lb) |
| A211 | Set to 0 to input a Greenwich ECI vector. Set to 1 to input a Besselian ECI vector. Set to 3 to input an IU telemetry vector. |
| A70-78 | P05 matrix only if a Besselian vector is input (Input the P05 matrix row-wise.) |
| BTEM31 | Set to 0 if the input vector units are km-m/sec or er-er/hr. Set to 1 if the input vector units are ft-ft/sec. |
| BTEM32 | Set to GMTIUGRR-GMTL/O in sec only if an IU vector is input. |
| BTEM33 | Generate updated ARRS input deck for tracking |
| TRA Card | Terminates the input for a case. |
| Columns | |
| 8-10 | TRA (A3) |
| 12-14 | 2, 4 (A3) |

Note: Additional cases are input by repeating Cards 2 through the TRA card.

5.6.2 <u>Aerodynamics and Mass Properties Processor.</u> - The Aerodynamics and Mass Properties processor will be used to determine the CSM entry aerodynamics as well as the CSM center of gravity location, moments of inertia, and engine trim angles at any time during the mission. The processor is composed of four options from which the CM trim aerodynamics, CSM center of gravity location, mass properties table, and digital autopilot command load can be generated.

# AERODYNAMICS AND MASS PROPERTIES PROCESSOR

## (IBM 7094 and UNIVAC 1108)

### On-Line Card Input

Card 1 — File number

    Columns

        1-2 — 02

Card 2 — Calculation option (I1)

    Column

        3

        1   Generate the aerodynamics table of the present vehicle.

        2   Determine the new center of gravity location of the vehicle after adding or subtracting the designated modules.

        3   Generate the mass properties table.

        4   Generate the digital autopilot load.

Option 1

Card 3 — Parameters of present vehicle

    Columns

        1-10 — Weight of present vehicle (E10)

        11-20 — $X_{cg}$ - X station of center of gravity (E10)

        21-30 — $Y_{cg}$ - Y station of center of gravity (E10)

        31-40 — $Z_{cg}$ - Z station of center of gravity (E10)

        41-52 — Comments (A12)

Option 2

Card 3

    Columns

        1-3 — Number of modules to be input for a run (I3)

Card 4 — Parameters of the modules

    Columns

        1-10 — Weight of module; plus if it is to be added or minus if it is to be subtracted (E10)

        11-20 — $X_{cg}$ - X station of center of gravity of module (E10)

        21-30 — $Y_{cg}$ - Y station of center of gravity of module (E10)

        31-40 — $Z_{cg}$ - Z station of center of gravity of module (E10)

The following inputs are needed on Card 4 if new spacecraft moments of inertia are to be calculated:

Columns

| | | |
|---|---|---|
| 41-50 | $I_{XX}$ | - Moment of inertia of the module about the X-axis (E10) |
| 51-60 | $I_{YY}$ | - Moment of inertia of the module about the Y-axis (E10) |
| 61-70 | $I_{ZZ}$ | - Moment of inertia of the module about the Z-axis (E10) |

Card 5                    Options for each case in the run:

Columns

| | | |
|---|---|---|
| 1-3 | | Number of modules for a case (I3) |
| 4-6 | 1 | Compute aerodynamics (I3). |
| | 0 | Do not compute aerodynamics (I3). |
| 7-9 | 1 | Use only those modules specified on Card 6 for a case (I3). |
| | 0 | Use the first N modules for a case where N is the number in Col. 1-3 and Card 6 is not included for the case (I3). |
| 11-22 | | Comments (A12) |

Card 6                    Modules to be used for a case (I3):

Columns

| | |
|---|---|
| 1-3 | Each number in fields 1-3, 4-6, etc., corresponds |
| 4-6 | to the order in which the modules were input (e.g. |
| . | to use the second and fourth of the input modules |
| . | for a case (Col. 1-3) = 002, (Col. 4-6) = 004 and |
| 74-76 | (Col. 7-76) = blank). |

Note: Additional cases are input by repeating Card 5 and also Card 6 if necessary. Place two blank cards at the end of the on-line deck to terminate the input.

Option 3 and 4:

Card 3

Columns

| | |
|---|---|
| 1-10 | Option 3 - Input SPS mixture ratio (E10). |
| | Option 4 - Input thrust level (lb) (E10). |

| Card 4 | Command module |
|---|---|
| Columns | |
| 1-10 | Weight of module |
| 11-20 | $X_{cg}$ - X station of center of gravity of module (E10) |
| 21-30 | $Y_{cg}$ - Y station of center of gravity of module (E10) |
| 31-40 | $Z_{cg}$ - Z station of center of gravity of module (E10) |
| 41-50 | $I_{XX}$ - Moment of inertia of the module about the X-axis (E10) |
| 51-60 | $I_{YY}$ - Moment of inertia of the module about the Y-axis (E10) |
| 61-70 | $I_{ZZ}$ - Moment of inertia of the module about the Z-axis (E10) |
| Card 5 | Service module (same format as Card 4) |
| Card 6 | RCS quad A |
| Columns | |
| 1-10 | Weight (lb) (E10) |
| Card 7 | RCS quad B (same format as Card 6) |
| Card 8 | RCS quad C (same format as Card 6) |
| Card 9 | RCS quad D (same format as Card 6) |
| Card 10 | SPS fuel (same format as Card 6) |
| Card 11 | SPS oxidizer (same format as Card 6) |
| Card 12 | Primary $H_2$ (same format as Card 6) |
| Card 13 | Secondary $H_2$ (same format as Card 6) |
| Card 14 | Primary $O_2$ (same format as Card 6) |
| Card 15 | Secondary $O_2$ (same format as Card 6) |
| Card 16 | Potable water (same format as Card 6) |
| Card 17 | Waste water (same format as Card 6) |
| Cards 18-36 | These are optional cards for inputting additional modules and are the same format as Card 4. It is only necessary to input as many cards as there are additional modules. Place two blank cards at the end of the on-line deck to terminate input. |

### 5.6.3 Command Formatting and General Conversion Processor. -

This processor contains seven options in which data in engineering units are converted to octal or data in octal are converted to engineering units. Six of the options are concerned with up-linked or down-link CMC quantities and possess fixed formats, scale factors, and octal precisions. The seventh option is for general conversion from engineering units to octal, or vice versa, given the number, scale factors, precision, and multipliers if necessary.

# COMMAND FORMATTING AND GENERAL CONVERSION PROCESSOR

## (IBM 7094 and UNIVAC 1108)

### On-Line Card Input

| | |
|---|---|
| Card 1 | File number |
| Columns | |
| 1-2 | 03 |
| Card 2 | Processor and conversion options |
| Columns | |
| 1 | 1 Navigation update |
| | 2 Orbit external $\Delta V$ |
| | 3 Deorbit external $\Delta V$ |
| | 4 REFSMMAT |
| | 5 RTCC restart vector (numeric) |
| | 6 RTCC restart vector (alphanumeric) |
| | 7 General conversion |
| 2 | 0 Decimal to octal conversion (For processor option 6, this is alphanumeric to octal conversion.) |
| | 1 Octal to decimal conversion (For processor option 6, this is octal to alphanumeric conversion.) |

Processor option 1 or 5 for decimal to octal conversion:

| | |
|---|---|
| Card 3 | |
| Columns | |
| 1-20 | X position coordinate (ft) (E20) |
| Card 4 | Y position coordinate (ft) (same format as Card 3) |
| Card 5 | Z position coordinate (ft) (same format as Card 3) |
| Card 6 | X velocity coordinate (ft/sec) (same format as Card 3) |
| Card 7 | Y velocity coordinate (ft/sec) (same format as Card 3) |
| Card 8 | Z velocity coordinate (ft/sec) (same format as Card 3) |
| Card 9 | Vector time (GMT) |
| Columns | |
| 1-3 | Hours (I3) |
| 4-5 | Minutes (I2) |
| 6-10 | Seconds (E5) |

Processor option 1 or 5 for octal to decimal conversion, or processor option 6 for octal to alphanumeric:

Card 3

    Columns

       1-10          X position coordinate (km) (O10)

Card 4             Y position coordinate (km) (same format as Card 3)

Card 5             Z position coordinate (km) (same format as Card 3)

Card 6             X velocity coordinate (m/cs) (same format as Card 3)

Card 7             Y velocity coordinate (m/cs) (same format as Card 3)

Card 8             Z velocity coordinate (m/cs) (same format as Card 3)

Card 9             Vector time (cs) (same format as Card 3)

Processor option 2 with decimal to octal conversions:

Card 3             Ignition time (g. e. t. )

    Columns

       1-3           Hours (I3)

       4-5           Minutes (I2)

       6-10          Seconds (E5)

Card 4

    Columns

       1-20          External $\Delta V_x$ component (ft/sec) (E20)

Card 5             External $\Delta V_y$ component (ft/sec) (same format as Card 4)

Card 6             External $\Delta V_z$ component (ft/sec) (same format as Card 4)

Card 7             Vehicle weight (lb) (same format as Card 4)

Processor option 2 with octal to decimal conversion:

Card 3

    Columns

       1-10          Ignition time (sec) (O10)

Card 4             External $\Delta V_x$ component (m/cs) (same format as Card 3)

Card 5             External $\Delta V_y$ component (m/cs) (same format as Card 3)

Card 6             External $\Delta V_z$ component (m/cs) (same format as Card 3)

Card 7

    Columns

        1-5                Vehicle weight (kg) (O5)

Processor option 3 with decimal to octal conversion:

Card 3

    Columns

        1-20             Latitude of ignition (deg) (E20)

Card 4                      Longitude of ignition (deg) (same format as Card 3)

Card 5                      Ignition time (g. e. t.)

    Columns

        1-3                Hours (I3)

        4-5                Minutes (I2)

        6-10             Seconds (E5)

Card 6                      External $\Delta V_x$ component (ft/sec) (same format as Card 3)

Card 7                      External $\Delta V_y$ component (ft/sec) (same format as Card 3)

Card 8                      External $\Delta V_z$ component (ft/sec) (same format as Card 3)

Card 9                      Vehicle weight (lb) (same format as Card 3)

Processor option 3 with octal to decimal conversion:

Card 3

    Columns

        1-10            Latitude of ignition (deg) 0-360 degrees (O10)

Card 4                      Longitude of ignition (deg) 0-360 degrees (same format as Card 3)

Card 5                      Ignition time (cs) (same format as Card 3)

Card 6                      External $\Delta V_x$ component (m/cs) (same format as Card 3)

Card 7                      External $\Delta V_y$ component (m/cs) (same format as Card 3)

Card 8                      External $\Delta V_z$ component (m/cs) (same format as Card 3)

Card 9

    Columns

        1-5                Vehicle weight (kg) (O5)

Processor option 4 with decimal to octal conversion:

    Card 3

        Columns

            1-20           First element of REFSMMAT (E20)

    Cards 4-11          Elements of REFSMMAT input row-wise (same format as Card 3)

Processor option 4 with octal to decimal conversion:

    Card 3

        Columns

            1-10           First element of REFSMMAT (O10)

    Cards 4-11          Elements of REFSMMAT input row-wise (same format as Card 3)

Processor option 6 with alphanumeric to octal conversion:

    Card 3           X position component (km)

        Columns

            1-4            Most significant digits (A4)

            6-9            Least significant digits (A4)

    Card 4           Y position coordinate (km) (same format as Card 3)

    Card 5           Z position coordinate (km) (same format as Card 3)

    Card 6           X velocity coordinate (m/cs) (same format as Card 3)

    Card 7           Y velocity coordinate (m/cs) (same format as Card 3)

    Card 8           Z velocity coordinate (m/cs) (same format as Card 3)

    Card 9           Vector time (cs) (same format as Card 3)

Processor option 7 with decimal to octal conversion:

    Card 3

        Columns

            1-72           Comments (A72)

    Card 4

        Columns

            1-20           Decimal number to be converted to octal (E20)

            21-25          Scale factor (I5)

            26-30          Precision (I5)

            31-50          Multiplier of the number to be converted (E20)

Processor option 7 with octal to decimal conversion:

    Card 3

        Columns

            1-72        Comments (A72)

    Card 4

        Columns

            1-15        Octal number to be converted to decimal (O15)

            21-25       Scale factor (I5)

            26-30       Precision (I5)

            31-50       Divisor of the number to be converted (E20)

5.6.4 <u>K-Factor Processor</u>. - This processor will be used to compute the atmospheric density K-Factor for the RTCC. The K-Factor value is determined by propagating one input state vector to the time of a later input state vector. The value of the atmospheric density multiplier is adjusted until the propagated vector and the second state vector agree to some specified accuracy.

# K-FACTOR PROCESSOR

## (IBM 7094 and UNIVAC 1108)

### On-Line Card Input

| | | |
|---|---|---|
| Card 1 | | File number |
| Columns | | |
| 1-2 | | 04 |
| Card 2 | | Comparison option |
| Column | | |
| 1 | | 1 Compare each vector to the first vector. |
| | | 2 Compare each vector to the preceeding vector. |
| Card 3 | | |
| Columns | | |
| 1-10 | | Vehicle weight (lb) (E10) |
| 11-20 | | Vehicle reference area (ft$^2$) (E10) |
| 21-30 | | Drag coefficient (E10) |
| Card 4 | | Vector option |
| Column | | |

1 Vector is to be input in decimal rectangular coordinates (er, er/hr) (X, Y, Z, $\dot{X}$, $\dot{Y}$, $\dot{Z}$).

2 Vector is to be input in decimal rectangular coordinates (ft, ft/sec) (X, Y, Z, $\dot{X}$, $\dot{Y}$, $\dot{Z}$).

3 Vector is to be input in geodetic spherical coordinates (ft, ft/sec, deg) (V, $\gamma$, $\psi$, H, $\lambda$, $\phi_D$).

4 Vector is to be input in geocentric spherical coordinates (ft, ft/sec, deg) (V, $\gamma$, $\psi$, R, $\lambda$, $\phi_C$).

5 Vector is to be input in classical orbital elements (ft, ft/sec, deg) (a, e, i, g, h, l).

6 Vector is to be input in octal rectangular coordinates (er, er/hr) (X, Y, Z, $\dot{X}$, $\dot{Y}$, $\dot{Z}$).

11-20 $K_1$-guess K-factor (E10)
$K_2$-guess K-factor (E10)  } Must be input and be reasonable values.
$K_3$-guess K-factor (E10)

| | | |
|---|---|---|
| Card 5 | | |
| Columns | | |
| 12-15 | | Vector identification (A4) |

Card 6              Vector time (GMT)

    Columns

        12-15        Hours (E4)

        17-19        Minutes (E3)

        21-25        Seconds (E5)

Card 7              Lift-off time (GMT)

    Columns

        12-15        Hours (E4)

        17-19        Minutes (E3)

        21-25        Seconds (E5)

Card 8

    Columns

        12-14        Revolution number (I3)

For vector option  1    2    3    4    5:

    Card 9

        Columns

| Columns | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| 1-20 | $X$ | $\dot{X}$ | $V$ | $V$ | $a$ | (E20) |
| 21-40 | $Y$ | $\dot{Y}$ | $\lambda$ | $\lambda$ | $e$ | (E20) |
| 41-60 | $Z$ | $\dot{Z}$ | $\psi$ | $\psi$ | $i$ | (E20) |

    Card 10

        Columns

| Columns | | | | | | |
|---|---|---|---|---|---|---|
| 1-20 | $X$ | $\dot{X}$ | $H$ | $R$ | $g$ | (E20) |
| 21-40 | $Y$ | $\dot{Y}$ | $\lambda$ | $\lambda$ | $h$ | (E20) |
| 41-60 | $Z$ | $\dot{Z}$ | $\phi_D$ | $\phi_C$ | $l$ | (E20) |

For vector option 6:

    Card 9

        Columns

           12-23        X(O12)

           25-36        Y(O12)

           38-51        Z(O12)

Card 10

Columns

| 12-23 | X (O12) |
|-------|---------|
| 25-36 | Y (O12) |
| 38-51 | Z (O12) |

Note: Additional vectors are input by repeating Cards 5-10. Place an end-of-file card at the end of the on-line deck to terminate the input.

5.6.5 <u>PVT Equation Processor.</u> - This processor will be used to determine the amount of oxidizer and fuel remaining in each tank and how much of this can be considered useful propellant. Using onboard values of helium temperature and pressure, the processor employs the real gas equation to determine the volume of helium used to pressurize the fuel-oxidizer system. Once the volume of helium is determined in each tank, the amount of fuel or oxidizer is computed from the known total volume of each tank. The amount of useable propellant is then determined from the fuel to oxidizer mixture ratio being used and the ability (efficiency) of each tank to expel all its contents.

# PVT EQUATION PROCESSOR

## (IBM 7094 and UNIVAC 1108)

### On-Line Card Input

| | |
|---|---|
| Card 1 | File number |
| Columns | |
| 1-2 | 05 |
| Card 2 | Tank Logic for each Quad (E10) |
| Columns | |
| 1-10 | Quad A |
| 11-20 | Quad B |
| 21-30 | Quad C |
| 31-40 | Quad D |
| Card 3 | Source pressure (lb/in$^2$) (same format as Card 2) |
| Card 4 | Temperature (deg) (same format as Card 2) |
| Card 5 | Delta temperature (deg) (same format as Card 2) |
| Card 6 | Oxidizer pressure (lb/in$^2$) (same format as Card 2) |
| Card 7 | Fuel pressure (lb/in$^2$) (same format as Card 2) |
| Card 8 | Mixture ratio 1 (same format as Card 2) |
| Card 9 | Mixture ratio 2 (same format as Card 2) |
| Card 10 | Oxidizer remaining (lb) (same format as Card 2) |
| Card 11 | Fuel remaining (lb) (same format as Card 2) |

Note: Place two blank cards at the end of the on-line deck to terminate the input.

5.6.6 <u>REFSMMAT Processor.</u> - This processor will compute the REFSMMAT that will be used from lift-off until the IMU is realigned in orbit. The REFSMMAT is computed from the launch pad location, flight azimuth, time of guidance reference release (GRR), and the values of the precession and nutation angles.

# REFSMMAT PROCESSOR

## (IBM 7094)

### On-Line Input

Card 1

    Columns

        1-2            06

File number

Card 2

    Columns

       1-20       Longitude of pad; $0 \leq \deg \leq 360$ (E20)

      21-40      Latitude of pad; $0 \leq \deg \leq 90$ (E20)

      41-60      Altitude of pad (m) (E20)

Card 3

    Columns

       1-20       AXO* is the angular rotation about +X (rad) (E20)

      21-40      AYO* is the angular rotation about -Y (rad) (E20)

      41-60      CAZ is flight azimuth; $0 \leq \deg \leq 360$ (E20)

Card 4

    Columns

       1-20       TEPHEM is the time from Besselian reference to midnight prior to launch (sec) (E20).

      21-40      TGRR is the time from midnight prior to launch to guidance reference release (sec) (E20).

      41-60      CAZO is the Greenwich hour angle, or rotation about Z between +X and the Greenwich meridian at midnight prior to launch; $0 \leq CAZO \leq 360$ (E20).

---

*AXO and AYO are the precession and nutation angles and the values may be obtained from NASA-FAB.

5.6.7 <u>Spacecraft-to-Sun Alignment Processor.</u> - The Spacecraft-to-Sun Alignment processor will be used to determine the IMU gimbal angles required to orient the CSM so that a given location on the spacecraft body will be pointed at the sun. This location is specified by pitch and yaw angles from the spacecraft X-axis.

# SPACECRAFT-TO-SUN ALIGNMENT PROCESSOR

## (IBM 7094 and UNIVAC 1108)

### On-Line Card Input

| | |
|---|---|
| Card 1 | File number |
| Columns | |
| 1-2 | 07 |
| Card 2 | |
| Columns | |
| 1-20 | Greenwich hour angle (deg) |
| 21-40 | Yaw* from spacecraft X-axis (deg) |
| 41-60 | Declination of sun (deg) |
| 61-80 | Pitch* from spacecraft X-axis (deg) |
| Card 3 | REFSMMAT input row-wise (E10) |
| Columns | |
| 12-20 | REFSMMAT (1, 1) |
| 22-30 | REFSMMAT (1, 2) |
| 32-40 | REFSMMAT (1, 3) |
| Card 4 | REFSMMAT (2, 1), (2, 2), (2, 3)(same format as Card 2) |
| Card 5 | REFSMMAT (3, 1), (3, 2), (3, 3)(same format as Card 3) |
| Card 6 | P05 matrix input row-wise (E10) |
| Columns | |
| 1-20 | P05 matrix (1, 1) |
| 21-40 | P05 matrix (1, 2) |
| 41-60 | P05 matrix (1, 3) |
| Card 7 | P05 matrix (2, 1), (2, 2), (2, 3)(same format as Card 6) |
| Card 8 | P05 matrix (3, 1), (3, 2), (3, 3)(same format as Card 6) |

---

*These two angles are used to locate the position on the spacecraft to be directed towards the sun.

5.6.8 Mass Properties/Reaction Control System/Service Propulsion System (MRS) Processor. - The MRS processor will be used to generate a complete reaction control system propellant budget using previously supplied data for individual maneuver propellant consumption and internally computed mass properties characteristics. During the mission, as propellant is expended and vehicle configuration modified, the RCS portion of the processor will accept inputs from the mass properties portion for use in its computations. In addition to mass properties, the RCS portion uses a form of flight timeline which is input by the user and fixed data which are stored in the program. The processor is used in real-time mission support to correct the preflight budget in accordance with changes in the basic flight plan or procedure and can include certain failure situations. The on-line inputs for this processor were not available at the time of this writing and will be published at a later date.

5.6.9 Solar Particle Alert Network (SPAN) Processor. - Although this processor is being developed for the high ellipse Apollo missions, the Apollo 7 flight will be used to check out the processor and the procedures to be implemented for its effective use. The processor will receive solar flare data from the Solar Particle Alert Network in the form of a punched paper tape and reduce the data in order to determine the radiation hazard in the earth's vicinity. The on-line inputs for this processor were not available at the time of this writing and will be published at a later date.

# 6. OPERATING INSTRUCTIONS FOR THE RTACF ORBITAL LIFETIME PROGRAM

## 6.1 General

This section presents the on-line inputs to the Apollo 7 Orbital Lifetime Program; a brief discussion of the purpose of the program; and the tape setup and control cards required to operate the program on the IBM 7094 data processing system.

## 6.2 Program Description

This program will be used to compute the predicted orbital lifetime of a space vehicle given a state vector, the aerodynamic characteristics of the vehicle, and the model atmosphere to be used.

## 6.3 Tape Setup for the IBM 7094 Data Processing System

| Tape Unit | Tape Description |
|-----------|------------------|
| A1 | MSFC system tape |
| B1 | Program tape |
| A3 | Output tape |

## 6.4 Inputs to the Orbital Lifetime Program

The inputs to the orbital lifetime program are given on the following pages.

# ORBITAL LIFETIME PROGRAM

## (Special Tape; IBM 7094 Only)

Card 1            Vector input option

  Columns

     2              0 Vector will be in octal (I1).

                      1 Vector will be in decimal (I1).

     5              0 Units of the vector (er, er/hr) (I1)

                      1 Units of the vector (ft, ft/sec) (I1)

   7-12          Atmosphere option - format (A6)

                      SPECUS  Special 1962 U. S. Standard atmosphere

                      ARDC     1959 ARDC atmosphere

                      USSTD    1962 U. S. Standard atmosphere

                      POE       Poe atmosphere

                      SMALL   H. Small atmosphere

                      SPECAR  Special 1959 ARDC atmosphere

Card 2            Vector identification

  Columns

  13-31         Three six-character words (A18)

Card 3            Lift-off time (GMT)

  Columns

  12-14         Hours (E3)

  16-18         Minutes (E3)

  20-23         Seconds (E4)

  25-27         Month (E3)

  29-31         Day (E3)

  33-37         Year (E5)

Card 4            Vector time (GMT)

  Columns

  12-15         Hours (E4)

  17-19         Minutes (E3)

  21-24         Seconds (E4)

  26-28         Month (E3)

  30-32         Day (E3)

  34-38         Year (E5)

Card 5

Columns

| | |
|---|---|
| 1-10 | Vehicle weight (lb) |
| 11-20 | Vehicle reference area (sq ft) |
| 21-30 | Vehicle drag coefficient if not equal to +2.0 |

Card 6      Stop time for density K-factor computation (hr, min, sec) (g.e.t.). Use blank card if no density K-factor is to be computed.

Columns

| | |
|---|---|
| 1-4 | Hours (F5) |
| 5-7 | Minutes (F3) |
| 8-10 | Seconds (F3) |

Card 7      Position coordinates

Columns

| | |
|---|---|
| 12-31 | X (E20) |
| 33-52 | Y (E20) |
| 54-73 | Z (E20) |

Card 8      Velocity coordinates

Columns

| | |
|---|---|
| 12-31 | $\dot{X}$ (E20) |
| 33-52 | $\dot{Y}$ (E20) |
| 54-73 | $\dot{Z}$ (E20) |

Octal vector option

Card 7      Position coordinates

Columns

| | |
|---|---|
| 12-23 | X (O12) |
| 25-36 | Y (O12) |
| 38-51 | Z (O12) |

Card 8      Velocity coordinates

Columns

| | |
|---|---|
| 12-23 | $\dot{X}$ (O12) |
| 25-36 | $\dot{Y}$ (O12) |
| 38-51 | $\dot{Z}$ (O12) |

# 7. OPERATING INSTRUCTIONS FOR THE APOLLO REAL-TIME RENDEZVOUS SUPPORT (ARRS) PROGRAM

## 7.1 General

This section presents a description of the ARRS program, a pictorial representation of the input data deck, and the tape setup and control cards required to operate the ARRS as an off-line program on the IBM 7094 and UNIVAC 1108 data processing systems. Also included is a description of the tape setup and a sequence listing of the input data deck required to operate the ARRS through the IBM 7094 on-line card reader.

## 7.2 Program Description

ARRS is composed of a number of processors and routines required to support a rendezvous mission. Those which will be of concern to the Apollo 7 mission are described below:

- The General Purpose Maneuver Processor (GPMP) is used to compute impulsive maneuvers at a specified point in an orbit to achieve desired orbital conditions.

- The Two-Impulse and Terminal Phase Processor computes a set of two maneuvers by specifying when they should be performed and by specifying the conditions, such as phase and height offsets, after the final maneuver point.

- The Mission Plan Table (MPT) Processor accepts vectors before and after impulsive maneuvers and computes the required finite burn quantities necessary to achieve the orbit after the maneuver.

- The Relative Print Routine computes relative quantities, such as range, range rate, and look angles, between two orbiting vehicles.

- The Tracking Routine computes the tracking station coverage of a vehicle from the initial vector through all the maneuvers in the Mission Plan Table.

- The Concentric Rendezvous Processor computes a rendezvous plan by using concentric flight plan logic. This processor may be used to compute the second maneuver of the two impulse rendezvous plan after the first maneuver has been executed by the spacecraft, a capability non-existent in the Two-Impulse and Terminal Phase Processor.

- The Conversion Routine converts vectors from one coordinate system to a number of other coordinate systems.

- The Trajectory Update Routine accepts a tracking vector, executes the maneuvers in the MPT, and recomputes tracking station coverage.

7.3 Tape Setup for the IBM 7094 Data Processing System

| Tape Unit | Tape Description |
|---|---|
| A1 | MSFC IBSYS system tape |
| B1 | ARRS program tape |
| A3 | Off-line output tape |

7.4 Tape Setup for the UNIVAC 1108 Data Processing System

| Tape Unit | Tape Description |
|---|---|
| X | ARRS program tape |

7.5 Control Card Listing for the IBM 7094 Data Processing System

```
$JOB
$PAUSE MOUNT TAPES
$RELOADGPMSMT
```

7.6 Control Card Listing for the UNIVAC 1108 Data Processing System

| Column | 1 | 4 | 8 | |
|---|---|---|---|---|
| | $JOB | | | NASA/MSC standard job card |
| | ▽N | HDG | | Comments |
| | ▽ | ASG | X = XXXX | Program (ARRS) tape number |
| | ▽ | XQT | CUR | Execute the following instructions: |
| | | TRW X | | Rewind unit X. |
| | | IN X | | Read in first file of tape X. |
| | | TRI X | | Rewind tape X. |

∇  XQT ARRS                    Execute the ARRS program.

         ·    ⎤
         ·    ⎟
         ·    ⎟
         ·    ⎬          ARRS data cards
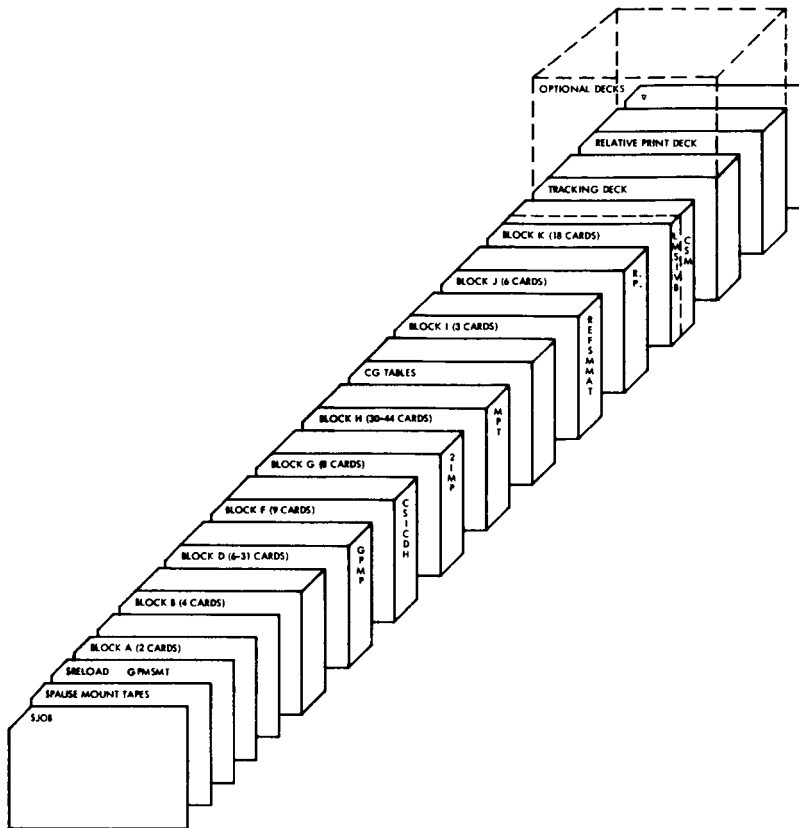         ·    ⎟
         ·    ⎟
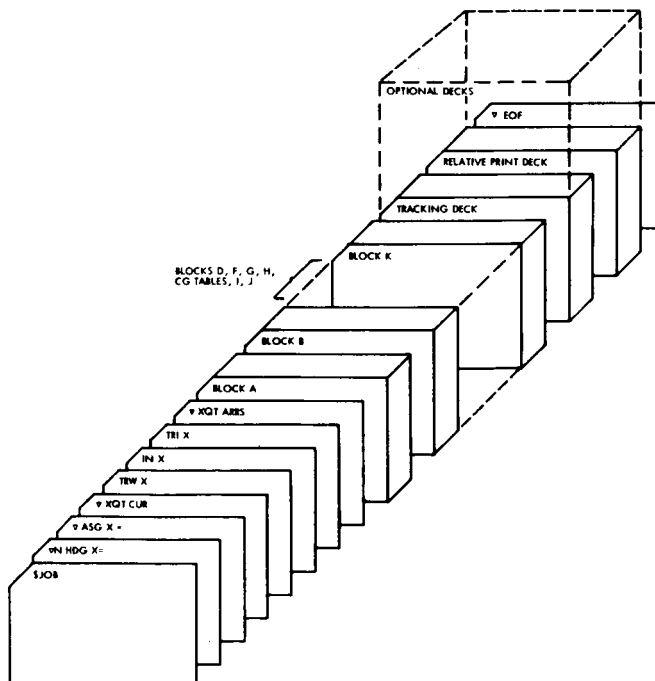         ·    ⎦
∇  EOF                         Terminate the run.

## 7.7 IBM 7094 Deck Setup



## 7.8 UNIVAC 1108 Deck Setup

## 7.9  Inputs to the ARRS Program

A complete description of the input variables for the ARRS Program is presented in Reference 4.  The inputs for some of the special applications are listed below:

Vector Conversion. - The ARRS has the capability of converting input vectors from one coordinate system to a number of other coordinate systems.  The routine may be used as a separate processor, or it may be used in conjunction with any other processor.  In the first instance, the routine is under the control of the KDC flag in Block A.  When this flag is set to zero, the GPMP and rendezvous processors are bypassed and the input vectors are converted to classical elements (a, e, i, g, h, l), spherical elements (V, $\gamma$, $\psi$, R, $\lambda$, $\phi$), and rectangular elements (X, Y, Z, $\dot{X}$, $\dot{Y}$, $\dot{Z}$).

The vectors which will be converted are determined by the IREL1 and IREL2 flags in Block J.  Options are available to have either, or both, vehicle one and two vectors converted at input time, after each maneuver in the Mission Planning Table, or at some specified time other than at input.  (The input vectors will be propagated to the specified time).

When used in conjunction with another ARRS processor, the KDC flag has no meaning to the conversion routine, and control is under the IREL1 and IREL2 flags of Block J.

Relative Print. - The relative print routine will compute the relative quantities, such as range, range rate, and look angles between the two orbiting vehicles.  Normally the routine is used in addition to a rendezvous sequence to verify approach, but it may be used as a separate processor.  In either case, the routine is under the control of the KDC flag in Block A.  Options are available to compute the relative quantities from an input vector (or a previously computed vector) forward or backward to another previously computed vector or for some specified period of time.

In addition, the relative print routine may be used to coast a docked vehicle configuration to some point in time (using the combined weights of both vehicles).  After the advancement, the vehicles will be considered separated and will have their separate weights.

Radar Tracking. - This routine will compute the tracking station coverage of a vehicle from the time of the input vector through all maneuvers in the Mission Plan Table.  The routine may be used with any of the ARRS processors.  Control of the tracking routine is under the KK7 flag in Block A.  Tracking data will be computed for the number of stations set in KK7.

Block L is used to input tracking station coordinates, tracking intervals, minimum elevation angle, and to specify the vehicle to be tracked.  At present there are 24 stations processed by this routine.

The "tracking deck" is currently set up to process all 24 stations, using a minimum elevation angle of 5 degrees, for CSM tracking. It is set up to output tracking for 3 hours after the last maneuver in the MPT and for one complete day after each other maneuver in the MPT.

Deck Stacking. - Since the ARRS program only has the capability to process six maneuvers in one run, runs may be stacked if more maneuvers are to be processed. An example might be to process four orbit maneuvers prior to the rendezvous sequence of four maneuvers. In this case, two GPMP decks should be stacked. The first will execute the four orbit maneuvers. The second deck will write the MPT on a tape (specified by KTAPE=4 in Block A) and then process the rendezvous sequence.

In order to stack the above cases, two complete GPMP decks must be assembled and the second deck placed immediately behind Block K of the first. The second deck must be configured to accept the vectors computed by the first. This is accomplished by setting the UMFAP, MANU1, and MANU2 flags in Block J.

ARRS Vector Convention. - Vectors may be input in several coordinate systems and in several units. The flags ISET and ICON of Block K govern the input in the following manner:

ISET=1     Octal vector

     ICON=0      Canonical

         =1      Non-canonical

         =2      er and er/hr

ISET=2     Decimal vector

     ICON=0      Canonical

         =1      ft and ft/sec

         =2      n mi and ft/sec

         =3      er and er/hr

ISET=3     Geodetic spherical vector

     ICON=0      ft and ft/sec and deg

ISET=4     Classical orbital vector

     ICON=0      ft and deg

         =1      ft and rad

ISET=5     Geocentric spherical vector

     ICON=0      ft and ft/sec and deg

ISET=6     Ha, Hp, i, g, h, f

     ICON=0      n mi and deg

         =1      n mi and rad

ARRS Time Convention. - In Block B, on Card 4, fields 2 - 5 are used to input lift-off time in GMT. This enables the user to input vectors, maneuvers, etc., in g.e.t. If the lift-off time is not input on this card, all other times must be input in GMT.

Caution must be exercised, however, when processing Block G (two-impulse) and inputting the time of the second maneuver ($T_2$). If $T_2$ is to be added to the lift-off time in Block B and used as input to the two-impulse solution automatically, a non-zero digit must be punched in Column 49 of the $T_2$ card.

## 7.10 The RTACF-ARRS Basic Deck Processor

7.10.1 Description of the RTACF-ARRS Basic Deck Processor. - The RTACF-ARRS basic deck processor will be used to update a master ARRS deck stored on tape. On-line cards containing corresponding sequence I.D.'s to the master deck (the I.D.'s are shown in Section 7.10.3) are used by the processor to generate a new deck on tape. This deck is composed of the master deck and the updates that replaced cards in the master deck and is ready to be used as an ARRS data deck.

Special instructions for the on-line deck are listed below:

- Card I.D.'s start in Column 1.

- The first input variable field on a card starts in Column 4.

- Columns 73-80 may be used for comments.

- The first card in the on-line deck must be a $JOB card.

- The last card in the on-line deck must contain FILE starting in Column 1.

- To update c.g. tables, the first card of the on-line c.g. tables contains the I.D. (CG1). The program then reads in 79 additional ordered updates to the master deck.

- There is no capability to update tracking stations.

- To generate a new master deck containing on-line updates, a 1 should be punched in Column 72 of the FILE card. The master tape is generated on tape unit A5 and no ARRS deck is produced.

## 7.10.2 Tape Setup for the IBM 7094 Data Processing System

| Tape Unit | Tape Description |
|-----------|------------------|
| A1 | IBSYS |
| A2 | ARRS basic deck processor |
| A3 | Off-line output tape |
| A5 | New data tape (scratch) |
| B1 | Scratch |

After execution of the Basic Deck processor

| | |
|-----------|------------------|
| A1 | IBSYS |
| A2 | New data tape |
| A3 | Off-line output tape |
| B1 | ARRS tape |

## 7.10.3 Card Identifications for the ARRS On-line Input

The card identifications needed to operate the Basic Desk processor are presented on the following pages.

| Card ID | Input Variables | Format |
|---------|-----------------|--------|
| A1 | KDC, KK7, MANVEH, KTAPE, IDIS | 5I5 |
| A2 | BYEAR, BMON, BDAY, BHOUR, BMIN, BSEC | 6F12.1 |
| B1 | DOS, WT, DELH, DET | 4F12.1 |
| B2 | ALAMO, PHIS, ALAMS, PHIR, ALAMR, TSUN | 6F12.1 |
| B3 | $WDRY_1$, $GASL_1$, $DVLEFT_1$, $WDRY_2$, $GASL_2$, $DVLEFT_1$ | 6F12.1 |
| B4 | DUR, DAY, HR, MIN, SEC | 5F12.1 |
| D1 | NUMAN | 1I5 |
| D2 | MN, IVEHG, NM, KMLO | 4I5 |
| D3 | DPC, ALONG, HICIR, DHLONG, ALF, SHNODE | 6F12.1 |
| D4 | HAD, HPD | 2F12.1 |
| D5 | DAY, HOUR, MIN, SEC | 4F12.1 |
| D6 | GPDELV, YAW, PITCH | 3F12.1 |
| 2D2-2D6 | Second Maneuver | |
| 3D2-3D6 | Third Maneuver | |
| 4D2-4D6 | Fourth Maneuver   Same as D2-D6 | |
| 5D2-5D6 | Fifth Maneuver | |
| 6D2-6D6 | Sixth Maneuver | |

| Card ID | Input Variables | Format |
|---------|----------------|--------|
| F1 | ICDH, KCDH, NCDH, KTPI, KTHETA, IPAR | 6I5 |
| F2 | NTPI, KDCSI, KDCDH, IPC, KTHPC, NN | 6I5 |
| F3 | KC, KD | 2I5 |
| F4 | DVMAX, DHD, DFD, RPMIN, T1MIN, T2MIN | 6F12.1 |
| F5 | ALTPI, TIMLIT | 2F12.1 |
| F6 | TCSID, TCSIH, TCSIM, TCSIS | 4F12.1 |
| F7 | TCDHD, TCDHH, TCDHM, TCDHS | 4F12.1 |
| F8 | TTPID, TTPIH, TTPIM, TTPIS | 4F12.1 |
| F9 | THPCD, THPCH, THPCM, THPCS | 4F12.1 |
| G1 | DELTM, DTVIN, DPA, DH, DELTAT, TREQ | 6F12.1 |
| G2 | DHMIN, DHINC, DHMAX, DELPIT | 4F12.1 |
| G3 | LVC, IMAN, IOS, KODE, IBUT, IONE | 6I5 |
| G4 | TSRD, TSRH, TSRM, TSRS | 4F12.1 |
| G5 | TSRSD, TSRSH, TSRSM, TSRSS | 4F12.1 |
| G6 | TNCCD, TNCCH, TNCCM, TNCCS | 4F12.1 |
| G7 | T1D, T1H, T1M, T1S | 4F12.1 |
| G8 | T2D, T2H, T2M, T2S | 4F12.1 |

| Card ID | Input Variables | Format |
|---|---|---|
| H1 | $ULOV_{I,J}$ where $I = 1, 3$ and $J = 1, 2$ | 6F12.1 |
| H2 | $BUTHR_{I,J}$ where $I = 1, 3$ and $J = 1, 2$ | 6F12.1 |
| H3 | $BUTIM_{I,J}$ where $I = 1, 3$ and $J = 1, 2$ | 6F12.1 |
| H4 | $TOTHR_{I,J}$ where $I = 1, 3$ and $J = 1, 2$ | 6F12.1 |
| H5 | $TOTIM_{I,J}$ where $I = 1, 3$ and $J = 1, 2$ | 6F12.1 |
| H6 | $THRUST_{I,J}$ where $I = 1, 3$ and $J = 1, 2$ | 6F12.1 |
| H7 | $SPIV_{I,J}$ where $I = 1, 3$ and $J = 1, 2$ | 6F12.1 |
| H8 | $UTV_{I,J}$ where $I = 1, 3$ and $J = 1, 2$ | 6F12.1 |
| H9 | $TUB_{I,J}$ where $I = 1, 3$ and $J = 1, 2$ | 6F12.1 |
| H10 | $CANTU_{I}$ where $I = 1, 2$ | 2F12.1 |
| H11 | $XX_{I}$ where $I = 1, 4$ | 4F12.1 |
| H12 | $PX_{I}$ where $I = 1, 4$ | 4F12.1 |
| H13 | $YY_{I}$ where $I = 1, 5$ | 5F12.1 |
| H14 | $TOL_{I}$ where $I = 1, 5$ | 5F12.1 |
| H15 | ESTOP, ALAM | 2F12.1 |
| H16 | THTARG, CINP | 2F12.1 |
| H17 | $ENO_{I}$ where $I = 1, 6$ | 6F12.1 |

| Card ID | Input Variables | Format |
|---|---|---|
| H18 | TDKID, TDKIH, TDKIM, TDKIS | 4F12.1 |
| H19 | $KATTOP_I$ where I = 1,6 | 6I5 |
| H20 | $KAXOP_I$ where I = 1,6 | 6I5 |
| H21 | $KRCSS_I$ where I = 1,6 | 6I5 |
| H22 | $KROLL_I$ where I = 1,6 | 6I5 |
| H23 | $JJ_I$ where I = 1,6 | 6I5 |
| H24 | $IVH_I$ where I = 1,6 | 6I5 |
| H25 | $IBURN_I$ where I = 1,6 | 6I5 |
| H26 | K55, K56, KK3, KDEL | 4I5 |
| H27 | KSTART, KTOP, ITER | 3I5 |
| H28 | KTUP, KTARG, ITARG | 3I5 |
| H30 | $AOPEXT_I$ where I = 1,6 | 6F12.1 |
| H31 | $AOPEXT_I$ | 1F12.1 |
| CG1 | CG Tables (80 cards) | |
| A1018 | $CREFMT_{1,1}$, $CREFMT_{1,2}$, $CREFMT_{1,3}$ | 11XF10.1,2 (1XF10.1) |
| A1021 | $CREFMT_{2,1}$, $CREFMT_{2,2}$, $CREFMT_{2,3}$ | 11XF10.1,2 (1XF10.1) |
| A1024 | $CREFMT_{3,1}$, $CREFMT_{3,2}$, $CREFMT_{3,3}$ | 11XF10.1,2 (1XF10.1) |

| Card ID | Input Variables | Format |
|---------|-----------------|--------|
| J1 | IPLAY1, IPLAY2, IREL, IORBIT | 4I5 |
| J2 | DAY1, HOUR1, MIN1, SEC1 | 4F12.1 |
| J3 | DAY2, HOUR2, MIN2, SEC2 | 4F12.1 |
| J4 | DTREL, DDTREL | 2F12.1 |
| J5 | UNFAP, MANU$_1$, MANU$_2$ | 3I5 |
| J6 | XRELAT$_I$ where I = 1, 6 | 6F12.1 |
| K1 | ISET, ICON | 2I5 |
| K2 | GMDLO, GMHLO, GMMLO, GMSLO | 4F12.1 |
| K3 | VECDAY | 1F12.1 |
| B4871 | STA ID | 12XA4, 1XA3 |
| B1138 | VECHR, VECMIN, VECSEC | 11XF3.0, 1XF2.0, 1XF7.4 |
| B368 | REVNUM | 11XF3.0 |
| B240 | Position Vector | 11XE14.8, 1XE14.8, 1XE14.8 or 11XO12, 1XO12, 1XO12 |
| B248 | Velocity Vector | 11XE14.8, 1XE14.8, 1XE14.8 or 11XO12, 1XO12, 1XO12 |
| B280 | WHT | 11XF6.0 |
| K9 | CD, ARE | 2F12.1 |

First State Vector S-IVB (bracket spanning B4871 through B248)

| Card ID | Input Variables | Format |
|---|---|---|
| 2K1 | ISET, ICON | 2I5 |
| 2K2 | GMDLO, GMHLO, GMMLO, GMSLO | 4F12.1 |
| 2K3 | VECDAY | 1F12.1 |
| A4871 | STA ID | 12XA4, 1XA3 |
| A1138 | VECHR, VECMIN, VECSEC | 11XF3.0, 1XF20, 1XF7.4 |
| A368 | REVNUM | 11XF3.0 |
| A240 | Position Vector | 11XE14.8, 1XE14.8, 1XE14.8 or 11XO12, 1XO12, 1XO12 |
| A248 | Velocity Vector | 11XE14.8, 1XE14.8, 1XE14.8 or 11XO12, 1XO12, 1XO12 |
| A280 | WHT | 11XF6.0 |
| 2K9 | CD, ARE | 2F12.1 |
| | Relative Print Deck | |
| AA1 | KDC, KK7, MANVEH, KTAPE IDIS | 5I5 |
| AA2 | BYEAR, BMON, BDAY, BHOUR, BMIN, BSEC | 6F12.1 |
| BB1 | DOS, WT, DELH, DET | 4F12.1 |
| BB2 | ALAMO, PHIS, ALAMS, PHIR, ALAMR, TSUN | 6F12.1 |
| BB3 | $WDRY_1$, $GASL_1$, $DVLEFT_1$, $WDRY_2$, $GASL_1$, $DVLEFT_1$ | 6F12.1 |

| Card ID | Input Variables | Format |
|---|---|---|
| BB4 | DUR, DAY, HR, MIN, SEC | 5F12.1 |
| A1018 | $CREFMT_{1,1}$, $CREFMT_{1,2}$, $CREFMT_{1,3}$ | 11XF10.1, 2(1XF10.1) |
| A1021 | $CREFMT_{2,1}$, $CREFMT_{2,2}$, $CREFMT_{2,3}$ | 11XF10.1, 2(1XF10.1) |
| A1024 | $CREFMT_{3,1}$, $CREFMT_{3,2}$, $CREFMT_{3,3}$ | 11XF10.1, 2(1XF10.1) |
| JJ1 | IPLAY1, IPLAY2, IREL, IORBIT | 4I5 |
| JJ2 | DAY1, HOUR1, MIN1, SEC1 | 4F12.1 |
| JJ3 | DAY2, HOUR2, MIN2, SEC2 | 4F12.1 |
| JJ4 | DTRELL, DDTREL | 2F12.1 |
| JJ5 | UNFAP, $MANU_1$, $MANU_2$ | 3I5 |
| JJ6 | $XRELAT_I$ where I = 1, 6 | 6F12.1 |
| K1 | ISET, ICON | 2I5 |
| K2 | GMDLO, GMHLO, GMMLO, GMSLO | 4F12.1 |
| K3 | VECDAY | 1F12.1 |

7-15

| Card ID | Input Variables | Format |
|---|---|---|
| B4871 | STA ID | 12XA4, 1XA3 |
| B1138 | VECHR, VECMIN, VECSEC | 11XF3.0, 1XF2.0, 1XF7.4 |
| B368 | REVNUM | 11XF3.0 |
| B240 | Position Vector | 11XE14.8, 1XE14.8, 1XE14.8 or 11XO12, 1XO12, 1XO12 |
| B248 | Velocity Vector | 11XE14.8, 1XE14.8, 1XE14.8 or 11XO12, 1XO12, 1XO12 |
| B280 | WHT | 11XF6.0 |
| K9 | CD, ARE | 2F12.1 |
| 2K1 | ISET, ICON | 2I5 |
| 2K2 | GMDLO, GMHLO, GMMLO, GMSLO | 4F12.1 |
| 2K3 | VECDAY | 1F12.1 |

First State Vector - S-IVB (bracket spanning B240 and B248)

| Card ID | Input Variables | Format |
|---------|-----------------|--------|
| A4871 | STA ID | 12XA4, 1XA3 |
| A1138 | VECHR, VECMIN, VECSEC | 11XF30, 1XF20, 1XF7.4 |
| A368 | REVNUM | 11XF30 |
| A240 | Position Vector | 11XE14.8, 1XE14.8, 1XE14.8 or 11XO12, 1XO12, 1XO12 |
| A248 | Velocity Vector | 11XE14.8, 1XE14.8, 1XE14.8 or 11XO12, 1XO12, 1XO12 |
| A280 | WHT | 11XF6.0 |
| 2K9 | CD, ARE | 2F12.1 |

Second State Vector CSM

# 8. OPERATING INSTRUCTIONS FOR THE APOLLO BLOCK DATA PROGRAM

## 8.1 General

This section presents a brief description of the program, the tape setup, and the control card listing required for operating the program on the UNIVAC 1108 data processing system. The on-line inputs and detailed discussion of this program are available in the Apollo Block Data Program User's Manual (Reference 3).

## 8.2 Program Description

The Apollo Block Data Program (ABDP) has the capability of performing four basic simulations: orbit propogation, orbital maneuvers, deorbit maneuvers and atmospheric entry. Data for different types of deorbits will be computed by the ABDP for each revolution during the earth orbital portions of manned Apollo missions. These data will be made available to the flight crew in blocks of six revolutions and will be used to deorbit the spacecraft in the event of a contingency which necessitates rapid mission termination.

## 8.3 Tape Setup for the UNIVAC 1108 Data Processing System

| Tape Unit | Tape Description |
|-----------|------------------|
| C | Off-line output tape |
| D | Scratch tape |
| H | Data tape (optional) |
| J | Scratch tape |
| X | ABDP program (PCF) tape |

## 8.4 Control Card Listing for the UNIVAC 1108 Data Processing System

| Column 1 | 4 | 8 | |
|----------|-----|--------|---|
| $JOB | | | NASA/MSC standard job card |
| ∇N | HDG | | Comments |
| ∇ | ASG | C, D, J | Scratch units on FASTRAND |
| ∇ | ASG | H=XXXX | Data tape number |
| ∇ | ASG | X=XXXX | Program tape number |
| ∇ | XQT | CUR | Execute following instructions: |

```
                    TRW X      Rewind tape X.

                    IN X       Read in first file of tape X.

                    TRI X      Rewind tape X with interlock.

    ∇N  XQT         MAIN       (Execute ABDP)

    .

    . ⎤  ABDP
    . ⎬  data
    . ⎦  cards

    .

    .

    END OF DATA                (Last card of ABDP data cards)

    ∇   EOF                    (End of file)
```

## 8.5  Inputs to the Apollo Block Data Program

The inputs to the Apollo Block Data Program are presented in the Apollo Block Data Program User's Manual, (Reference 4).

# REFERENCES

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2. Task Agreement for Operational Support for the Real-Time Auxiliary Computing Facility, Task MSC/TRW A-130, Amendment No. 7 September 20, 1968.

3. Reini, W. A.: A Description of the Input to the Apollo Real-Time Rendezvous Support Program. MSC IN 67-FM-165, November 3, 1967.

4. Cunningham, H. H.: Apollo Block Data Program User's Manual (Revision 1). TRW Note 68-FMT-683, September 20, 1968.

5. NASA: SG-GEM Program User's Manual. (no number, undated)

6. Miller, R. D., West, R. S., Skillman, C. S. Jr.: CSM MRS Program Description. TRW Note 68-FMT-621, February 28, 1968.

7. Apollo 7 Spacecraft Operational Trajectory. Volume I, Mission Profile. MSC IN 68-FM-110, May 22, 1968.